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RADIATION DAMAGE OF MATERIALS: PART I - A GUIDE TO THE USE OF PLASTICS. ENGINEERING HANDBOOK

M.H. Van de Voorde, et al.

11 November 1966

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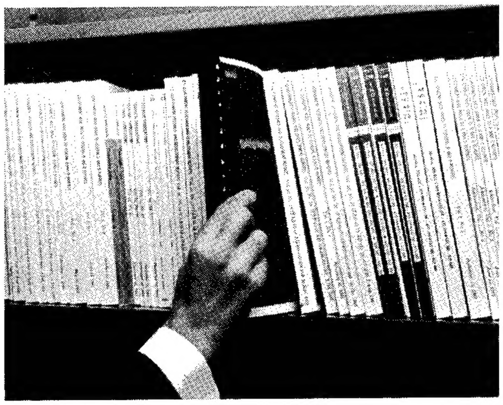

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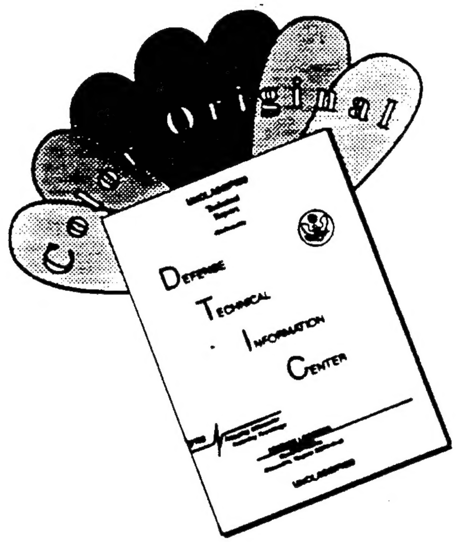

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RADIATION DAMAGE OF MATERIALS

ENGINEERING HANDBOOK

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M.H. Van de Voorde

and

G. Pluym

PART I: A Guide to the Use of Plastics

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PART I: A GUIDE TO THE USE OF PLASTICS

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A GUIDE TO THE USE OF PLASTICS

INTRODUCTION

The aim of design engineering is to select a material which will perform reliably under the most adverse conditions. A specific example of this is the growing need for materials which perform satisfactorily in radiation fields.

Plastics occupy a role of major significance in nuclear technology. They rank with metals and ceramics as the principal category of materials used in the construction of components in this field. Of all materials, organic materials are amongst those most sensitive to the effects of radiation.

The aim of this report is, therefore, twofold:

1. to give the general (mechanical, electrical, physical) properties of commercial plastics, and
2. to report the degeneration of these properties under nuclear radiation.

Thus, by cross reference, a guide is provided for the selection of plastics which has to fulfill specific requirements, even when subjected to high doses of absorbed radiation.

This engineering guide has shown itself to be all the more needed as data on radiation damage is scattered throughout - often not generally available - literature, measured under different conditions of irradiations, and thus often controversial in result. In reporting the data compiled in this report, exposures received by the various materials have, therefore, been expressed in a single unit of absorbed dose, the rad (= 100 ergs/gram). None of the data was taken during irradiation, only permanent effects have been reported.

RADIATION FIELDS AND CONVERSION FACTORS

Much of the published work on radiation effects on polymers is based on experiments carried out in the Oak Ridge reactor at

Tennessee and the BEPO reactor at Harwell. The pile unit employed at Oak Ridge corresponds to a neutron flux of 10^{18} thermal neutrons per cm^2, whereas at Harwell one pile unit is 10^{17} slow n/cm^2. The conversion factor from pile units to rads depends primarily on the elements present in the test specimen:

$$10^{18} \text{ nvt} = 10^9 \text{ rad for polyethylene}$$
$$10^{18} \text{ nvt} = 2.5 \times 10^9 \text{ rad for polyvinylchloride}$$
$$10^{18} \text{ nvt} = 7 \times 10^8 \text{ rad for polymethyl-methacrylate} \quad (1)$$

Electron irradiations are mostly done with a Van de Graaff generator. The total energy being delivered by the beam can be measured directly with a Faraday cup.

EXPLANATION OF TABLES AND FIGURES

A. Without Irradiation Effects

Tables 1 through 5 represent the physical, mechanical, electrical and thermal properties of:

thermoplastic moulding materials
thermoplastic sheet materials
thermoplastic films
thermosetting moulding materials, and
thermoset laminated sheets respectively.

Although the diversity of plastics is enormous, the choice for a given application will lie within a narrow band of the plastics spectrum. Within this band, however, there may be several plastics which approximate the needed requirements. Selecting the best one requires comparing the properties of each plastic. Tables 6 through 8 are a selection guide based on types of applications.

B. Irradiation Effects

Figures 1 and 2 show the relative radiation resistances of the most used thermoplastic and thermosetting resins.

The most evident and, from an engineering viewpoint, most important changes which occur in polymers under irradiation affect their mechanical properties. These changes for commercial plastics are shown in figs. 3 through 30 and table 2 for thermoplastics, and in figs 31 through 43 and table 10 for thermosettings.

The effect of nuclear radiation on volume resistivity, dielectric strength and arc resistance is given in table 11 for thermoplastics and in table 12 for thermosetting resins. The materials used are grouped in a logical order, firstly chemical composition, then by trade names. The exact composition of commercial products is often not known precisely, or even the composition may have changed, whereas the trade name remains.

Table 13 groups data on dielectric constant and dissipation factor of commercial plastics resistant to an absorbed dose of 10^9 rads.

(All tests were carried out according to ASTM norms.)

Values for the total gas evolved from irradiated samples of 0.2 to 0.5 gramme weight are listed in tables 14 and 15 for thermoplastics and thermosettings respectively. In general, the quantity of gas is proportional to the dosage, so extrapolation of the table to other doses is possible. The effects of oxygen and temperature are very important. The yields presented in the tables are for room temperature and in vacuum. Plastics containing only carbon and hydrogen atoms will primarily give off hydrogen during irradiation. Those containing oxygen, chlorine or fluorine will also give oxygen, chlorine and fluorine components.

The influence of fillers on the radiation resistance of some commercial plastics is shown in tables 16, 17 and 18 and figure 44. It can be concluded that the stability of the filled plastic is proportional to the radiation quality of the filler used.

Radiation stability of plastics at temperatures above the usual service temperature (→75° C.) are listed in tables 19 and 20 for thermoplastics and thermosettings. It can be seen that for high temperature applications only mineral filled plastics can be considered. Recommendable resins are phenolics, melamine formaldehyde and epoxies.

At cryogenic temperatures, epoxies have the highest mechanical properties, with phenolics and polyesters following in that order.

Most plastics are known by their trade names, two lists of which are added to this guide; one with the trade-names and one with the chemical composition in alphabetical order.

Table 1. Thermoplastic moulding materials (General bibliography p 118)

PROPERTY	Cellulosics					Polyamides				Poly-allomers	Poly-sulfones
	Cellulose Acetate	Cellulose Acetate Butyrate	Cellulose Acetate Propionate	Cellulose Nitrate	Ethyl Cellulose	Nylon 6'6	Nylon 6'10	Nylon 6	Nylon 11		
Specific gravity g/cm³	1,2 - 1,4	1,15 - 1,25	1,18 - 1,24	1,35 - 1,7	1,12 - 1,2	1,09 - 1,16	1,09	1,13 - 1,14	1,04 - 1,05	0,902	1,1
Water absorption %	0,65 - 6,0	0,5 - 2,5	1,2 - 2,8	0,6 - 2,0	0,5 - 1,5	0,8 - 1,5	0,3 - 0,4	1,9 - 6,2	0,2	< 0,01	-
Tensile strength lb/sq. in.	500 - 13.400	2.300-7.500	1.900-7.300	5.000-10.000	6.000-9.000	7.000-11.500	8.100-8.500	5.200-37.000	5.000-8.500	2.900 - 4.200	10.200
Impact strength ft lb (Izod per inch of notch)	0,2 - 9,9	0,5 - 6,5	0,5 - 11,0	4,0 - 8,0	2,0 - 8,5	1,0 - 4,0	1,3 - 4,0	0,62 - 6,0	7,5	1,5 - 12	1,3
Modulus of elasticity 10^5 lb/sq. in.	0,4 - 3,0	0,5 - 2,5	0,6 - 2,15	1,5 - 4,0	1,0 - 5,0	1,8 - 4,3	3,0	0,54 - 4,7	1,8	1 - 1,7	3,6
Elongation %	10 - 78	8 - 88	30 - 100	10 - 82	5 - 40	80 - 150	100 - 250	10 - 470	30 - 300	400 - 500	50 - 100
Flexural strength lb/sq. in	1.500-16.000	2.000-9.250	3.000-10.350	2.800-13.000	4.000-12.000	8.000-14.600	9.300	5.000-21.000	—	6.000 - 8.000	—
Volume resistivity ohms - cm	10^{10} - 10^{13}	10^{10} - 10^{13}	10^{12} - 10^{16}	10^{10} - 10^{13}	10^{12} - 10^{15}	10^{10} - 10^{14}	10^{14}	10^{11} - 10^{15}	10^{11} - 9×10^{13}	> 10^{15}	5.10^{16}
Surface resistivity ohms	4×10^{11}	10^{13}	—	—	—	9×10^{11}	9×10^{11}	2×10^{11} - 10^{14}	10^{12} - 2×10^{14}	> 10^{15}	3.10^{16}
Electric strength volts/mil	150-1.250	250 - 540	300 - 1.500	150 - 1.200	800 - 1.500	270 - 470	270 - 470	300 - 510	225 - 610	850	
Power factor 60 cycles/sec	0,01 - 0,2	0,01 - 0,04	0,01 - 0,04	0,03 - 0,15	0,007	0,01 - 0,09	0,02	0,011		10^2 c/s	0,0008-0,008
Power factor 10^6 cycles/sec	0,01 - 0,1	0,01 - 0,05	0,01 - 0,04	0,07 - 0,1	0,007-0,03	0,02 - 0,08	0,03	0,04 - 0,13	0,02 - 0,05	0,000.4	0,005 -0,0096
Dielectric constant 60 cycles/sec	3,5 - 7,5	3,5 - 6,4	10^2 c/s 3,7 - 4,0	6,0 - 8,0	2,7	3,9 - 7,6	3,6 - 3,9	3,4		10^2 c/s 2,5	2,8 - 3,1
Dielectric constant 10^6 cycles/sec	3,2 - 7,2	3,2 - 6,2	3,0 - 3,7	6,0	2,0 - 3,0	3,4 - 3,6	3,5	4,0 - 8,5	3,2 - 3,5		2,7 - 3,1
Softening point °C	51 - 115	58 - 94	50 - 120	49 - 71	49 - 66	250 - 264	220	210 - 220	180 - 190	150 - 140	160

Table 1. Thermoplastic moulding materials

PROPERTY		Polythene		Polypropylene	P.T.F.E.	P.C.T.F.E.	Styrene polymers			Styrene/ Acrylonitrile	Polycarbonate	Polyphenylene oxides
		Low density	High density				Gen. purposes	Toughened	ABS Co-polymers			
Specific gravity g/cm^3		0,91 - 0,93	0,936 - 0,96	0,90 - 0,91	2,1 - 2,3	2,1 - 2,3	1,04 - 1,07	1,04 - 1,07	1,01 - 1,07	1,07 - 1,1	1,2	1.06
Water absorption %		< 0,01	< 0,01	<0,03	0,005	0,00	0,03 - 0,04	0,03 - 0,3	0,57	0,15 - 0,3	0,2 - 0,4	0,10 27 days
Tensile strength lb/sq. in.		900 - 2.300	1.700-5.500	4.000-6.000	1.500-3.000	5.700-7.500	5.000-7.500	3.000-6.500	4.900-8.800	8.000-12.000	9.000-9.500	9.500-10.500
Impact strength ft lb (izod per inch of notch)		>16	1,0 - 20,0	0,5 - 4,0	>3,0	1,2 - 3,6	0,18 - 0,6	0,4 - 3,0	1,5 - 10,0	0,25 - 0,7	2 - 2,5	1,5 - 1,9
Modulus of elasticity 10^5 lb/sq. in.		0,13 - 0,33	0,5 - 10,3	1,3 - 1,7	0,58	1,35	1,5 - 5,0	2,5 - 5,5	2,5 - 3,5	4,0 - 6,0	3,1 - 3,5	3,7
Elongation %		125 - 800	20 - 600	220 - 900	100	35 - 190	1·0 - 3·6	10 - 40	15 - 30	2,0 - 4,0	60 - 100	80
Flexural strength lb/sq. in		no fracture	2.000-3.000	6.500-7.500	no fracture	7.110-8.250	9.000-13.000	7.000-17.000	8.000-13.500	11.500-19.000	11.000-13.000	14.500
Volume resistivity ohms-cm		5×10^{16}-10^{20}	$>3 \times 10^{16}$	3×10^{15}- 5×10^{16}	10^{17}-10^{20}	10^{18}	10^{17}-10^{21}	10^{12}-10^{17}	$>10^{15}$	7×10^{15}	10^{15}- $2,1 \times 10^{16}$	10^{17}
Surface resistivity ohms		$>4 \times 10^{14}$	10^{12}-10^{17}	$>10^{15}$	$3,6 \times 10^{12}$	10^{12}- 10^{13}	7×10^{17}	7×10^{17}	$>10^{14}$	7×10^{17}	6×10^{12}- 8×10^{12}	--
Electric strength volts/mil		440 - 1000	400 - 1,200	600 - 800	500	625	500 - 700	300 - 650	312 - 396	400 - 550	370 - 600	400 - 500
Power factor	60 cycles/sec	<0,005	0,0001	0,0005	0,0002	0,002 -0,0025	0,0002	0,0009	0,004-0,016	0,004-0,006	0,0007 - 0,0009	0,00035 - 0,0009
	10^6 cycles/sec	0,0002-0,002	>0,0001	0,0002-0,0003	0,0002	0,005-0,0085	0,0005	0,00012 - 0,002	0,007-0,03	0,001-0,01	0,01	
Dielectric constant	60 cycles/sec	2,2 - 2,3	2,3	2,2	2,0	2,3 - 2,4	2,5 - 2,65	2,45 - 4,75	2,76 - 4,76	2,9 - 3,4	2,95 - 3,3	2,58
	10^6 cycles/sec	2,3 - 2,35	2,3 - 2,35	2,0 - 2,15	2,0	2,1 - 2,5	2,5 - 2,65	2,4 - 4,0	2,44 - 3,78	2,8 - 3,1	2,9 - 3,0	2,58
Softening point °C		83 - 111	111 - 131	138 - 170	380 - 390	250 - 300	86 - 95	78 - 103	93 - 95	85 - 103	220 - 250	~ 250

Table 1. Thermoplastic moulding materials

PROPERTY	Polymethyl Methacrylate		Polyvinyl Chloride		Acetals	Phenoxics	Polyvinyl butyral	Polyvinyl formal			
	Cast	Moulded	Rigid	Flexible							
Specific gravity g/cm^3	1,19	1,19	1,35 - 1,60	1,14 - 1,45	1,14 - 1,42	1,182	1,08 - 1,12	1,20 - 1,25			
Water absorption %	0,18 - 0,4	0,3 - 0,4	0,07 - 0,4	0,1 - 0,75	0,12 - 0,4	0,13	0,3 - 0,6	1,0 - 1,3			
Tensile strength lb/sq. in.	8.000-10.000	8.000-11.500	4.000-9.000	1.000-3.500	8.800-10.000	9.500	4.000 - 8.500	9.000 - 11.000			
Impact strength ft lb (izod per inch of notch)	0,25 - 0,35	0,25 - 0,4	0,5 - 15	not applicable	1,2 - 2,3	2 - 5	1,2	0,4 - 2,0			
Modulus of elasticity 10^5 lb/sq. in.	3,9 - 4,4	3,8 - 4,5	4,1 - 5,0	0,008-0,02	1,78	3,8	3,5 - 4	5 - 7			
Elongation %	2 - 7	3 - 10	1 - 40	50 - 500	15 - 17	90	5 - 60	5 - 60			
Flexural strength lb/sq. in	12.000-17.000	13.000-17.000	10.000-16.000	not applicable	13.000-14.100	14.000	10.000	13.000 - 18.000			
Volume resistivity ohms-cm	$>10^{15}$	$>10^{15}$	5×10^{14} - 1×10^{15}	$5 \times 10^{[illegible]}$ - 5×10^{14}	1×10^{14} - 6×10^{14}	5.10^{13}	$>10^{14}$	-			
Surface resistivity ohms	$>10^{14}$	$>10^{14}$	10^{12} - 10^{13}	$>10^{14}$	$>2 \times 10^{13}$	-	-	-			
Electric strength volts/mil	380 - 390	240 - 310	500	250 - 750	500 - 1200	490	-	860 - 1.000			
Power factor 60 cycles/sec	0,05 - 0,0[illegible]	0,04 - 0,06	0,007 - 0,02	0,07 - 0,35	--	0,0012	0,007	0,007			
Power factor 10^6 cycles/sec	0,02	0,02 - 0,03	0,006 - 0,05	10^3c/s 0,1 - 0,128	10^2 - 10^5c/s 0,004	0,03	0,0065				
Dielectric constant 60 cycles/sec	2,7 - 2,9	3,5 - 4,5	3,2 - 3,6	5,0 - 9,0	--	4,1	3,61	3,7			
Dielectric constant 10^6 cycles/sec	3,25 - 4,25	2,7 - 3,2	2,[illegible] - 3,5	3,5 - 8,0	10^2 - 10^5c/s 3,7	3,8	3,33	3,0			
Softening point °C	90 - 115	85 - 115	75 - 165	not applicable	163 - 170	150 - 175	115	130 - 165			

Table 2. Thermoplastic sheet materials

PROPERTY	Cellulose Nitrate	Cellulose Acetate	Vinyl Chloride Polymers		Styrene Polymers		Polymethyl Methacrylate	Polythene		Polypropylene	Casein
			Rigid	Flexible	Toughened	ABS Copolymers		Low density	High density		
Specific gravity g/cm^3	1,35 - 1,8	1,2 - 1,6	1,3 - 1,6	1,2 - 1,6	1,04 - 1,11	1,01 - 1,10	1,19	0,91 - 0,93	0,936 - 0,96	0,90 - 0,91	1,32 - 1,39
Thermal conductivity 10^{-4}cal/sec cm^2 °C cm	3 - 5	5 - 8,5	3,5 - 4	3 - 4	1,9 - 2	4,64 - 6,3	3,5 - 5	7	10	3,3	-
Water absorption % 24 hr. immersion	1 - 3	0,7 - 3,5	0,015 -0,15	0,5 - 0,75	0,03 - 0,5	0,1 - 0,57	0,3 - 0,4	$<$ 0,01	$<$ 0,01	$<$ 0,03	3 - 7
Refractive index	1,5	1,5	1,52 - 1,54	-	not applicable	not applicable	1,49 - 1,495	1,52	1,54	-	not applicable
Tensile strength lb/sq. in.	3.000-8.000	2.800-7.650	6.000-10.000	2.800-9.000	3.200-4.000	4.800-7.500	6.900-10.800	1.500	3.000	4.000-4.200	4.500-10.000
Elongation %	20 - 40	25 - 44	4	230 - 500	10 - 40	100	2 - 7	450	625	350 - 600	-
Impact strength ft lb (izod per inch of notch)	4 - 8	2 - 7	0,2 - 0,7	not applicable	0,4 - 2	3,5 - 10,0	0,23 - 0,35	$>$3	1,0 - 20,0	0,5 - 4,0	1,0 - 1,5
Brinell hardness	8 - 20	6 - 13	12 - 20	not applicable	-	R 90 - 105	18 - 29	C 73 D 47 - 53 Shore	D 60 - 70 Shore	R 77 - 88	23
Flexural strength lb/sq. in.	9.000-11.000	1.000-7.000	10.000-14.000	not applicable	7.000-17.000	6.800-11.500	12.000-17.000	no fracture	2.000-3.000	6.000-9.000	-
Modulus of elasticity 10^5 lb/sq. in.	1,9 - 2	1,5 - 2,5	3,5 - 6	0,008 - 0,02	3,3 - 3,8	2,1	(3,9 - 4,82)x 10^5	(0,13-0,33)x 10^5	(0,5 - 10,3)x 10^5	(1,3-1,7) x 10^5	5,5 x 10^5
Compressive strength lb/sq. in.	22.000-35.000	4.000-25.000	9.900-11.300	-	12.000-16.000	7.000-11.000	12.000-18.000	-	-	5.460	-
Shear strength lb/sq. in	-	-	6.500-17.000	-	-	-	8.500-10.000	1.400-1.800	-	-	-
Volume resistivity ohms - cm	10^{10}-10^{12}	1,3 x 10^{10}- 5,5 x 10^{12}	10^{14} - 10^{16}	10^{12} - 10^{14}	10^{12} - 10^{17}	$>10^{15}$	$>10^{15}$	3 x 10^{16}-10^{20}	3 x 10^{16}-10^{18}	3 x 10^{15} - 5 x 10^{16}	5,8 x 10^9 - 11 x 10^9
Surface resistivity ohms	3 x 10^{10} - 3 x 10^{12}	4 x 10^{11} - 6,5 x 10^{12}	10^{13} - 10^{15}	$>10^{14}$	$>10^{15}$	$>10^{14}$	$>10^{14}$	$>$ 4 x 10^{14}	10^{12} - 10^{17}	$>10^{15}$	3,2 x 10^{10} - 8 x 10^{10}
Electric strength	150 - 600	325 - 800	350 - 650	550	300 - 650	312	250 - 390	440 - 1.000	510 - 1.200	750 - 1.000	216 - 700
Power factor	50 - 10^6c/s 0,03 - 0,0[illegible]	50 - 10^6c/s 0,02 - 0,06	50 - 10^6c/s 0,00[illegible]-0,05	50 - 10^6c/s 0,05 - 1,5	10^6 c/s 0,009-0,0012	10^6 c/s 0,007-0,012	10^6 c/s 0,02 - 0,05	10^6 c/s 0,00025	10^6 c/s 0,0001-0,001	10^6 c/s 0,0002-0,0003	10^6 c/s 0,052-0,06
Dielectric constant	50-10^6 c/s 6 - 8	60 c/s 4 - [illegible],4	50 - 10^6 c/s 3 - 4	10^6 c/s 3,5 - 8,6	60-10^6 c/s 2,4 - 4,75	10^6 c/s 2,59 - 3,78	10^3 - 10^6c/s 2,[illegible] - 3,5	10^6 c/s 2,2 - 2,3	10^6 c/s 2,3 - 2,35	10^6 c/s 2,0 - 2,2	10^6 c/s 6,1 - 6,8

Table 3. Thermoplastic films

PROPERTY	Cellulose Acetate	Cellulose Acetate Butyrate	Cellulose Triacetate	Ethyl Cellulose	Polycarbonate	Polythene		Polypropylene	Nylon	Polyethylene Teraphtalate	Polyimides
						Low density	High density				
Specific gravity g/cm^3	1,25 - 1,43	1,16 - 1,25	1,27 - 1,31	1,095 - 1,16	1,2	0,91 - 0,93	0,936 - 0,96	0,90 - 0,91	1,04 - 1,14	1,38 - 1,39	1,42
Water absorption % 24 hr. immersion	3,6 - 6,8	0,1 - 3,4	3,5 - 4,5	2,5 - 7,5	0,2 - 0,6	negligible	negligible	negligible	$<$ 3,3	$>$ 0,5	1,3
Moisture vapour permeability g/m^2/24 hr/mil thickness	55 - 634	177 - 935	155 - 237	155 - 780	—	18 - 21	3,8	9,5	0,5 - 800	1,9 - 28	0,2 – 2
Tensile strength lb/sq. in.	5.400-14.000	4.100-9.700	9.000-16.000	6.000-10.600	8.400-20.000	1.500-4.000	3.400-4.500	3.000-6.500	9.000	17.000-25.800	37.000
Tear strength Elmendorf g/mil	2 - 25	3 - 16	4 - 6	2 - 36	10 - 16	120 - 300	16 - 60	40 - 80	50 – 70	2 - 40	8 – 40
Elongation %	15 - 45	20 - 100	10 - 40	20 - 80	50 - 120	100 - 800	70 - 400	100 - 1.000	250 - 450	35 - 130	70– 100
Volume resistivity ohms-cm	10^{10} - 10^{12}	10^{14}	6 x 10^{13} - 5 x 10^{14}	10^{12} - 10^{15}	8 x 10^{15} - 3 x 10^{16}	3 x 10^{16} - 10^{20}	3 x 10^{16} - 10^{18}	5 x 10^{15} - 5 x 10^{16}	10^{10} - 10^{13}	10^{17} - 10^{19}	10^{18}
Surface resistivity ohms	4 x 10^{11}	$>$ 10^{14}	—	—	6 x 10^{12} - 8 x 10^{12}	$>$ 4 x 10^{14}	10^{12} - 10^{17}	$>$ 10^{15}	$>$ 10^{11}	—	10^{16} at 1 kV, 50% RH
Electric strength volts/mil	1.700-2.800	2.250-2.300	2.250-2.800	800-1.500	3.000-3.950	440-1.000	510-1.200	750-1.000	210 - 290	4.000	7.000
Power factor	50 c/s 0,018-0,02	8 x 10^2 c/s 0,012-0,024	8 x 10^2 c/s 0,019	60 c/s 0,007 10^6 c/s 0,007-0,03	50 c/s 0,0009-0,0025 10^6 c/s 0,0017-0,0098	10^6 c/s 0,00025	10^6 c/s 0,0001-0,001	10^6 c/s 0,0002-0,0003	50 c/s 0,06-0,1 10^6 c/s 0,04-0,13	32 - 32 x 10^3 c/s 0,003	10^3 c/s 0,003
Dielectric constant	50 c/s 4,9	8 x 10^2 c/s 3,5 - 4,1	8 x 10^2 c/s 3,9	60 c/s 2,7 10^6 c/s 2,0 - 3,0	50 c/s 3,0 - 3,1 10^6 c/s 2,0 - 2,98	10^6 c/s 2,2 - 2,3	10^6 c/s 2,3 - 2,35	10^6 c/s 2,0 - 2,2	50 c/s 6,7 - 14 10^6 c/s 4 - 4,7	32 - 32 x 10^3 c/s 2,9 - 3,2	10^3 c/s 3,5
Softening heat sealing temperature °C	140 - 260	60 - 121	-	99 - 132	220 - 250	115 - 120	135 - 191	160 - 170	190	230 - 260	[illegible]

Table 3. Thermoplastic films

PROPERTY	Vinyl Chloride Polymers and Copolymers		Polyvinylidene Chloride	Rubber Hydrochloride	Polyvinyl Alcohol	Polystyrene	Parylenes	Fluorocarbon	
	Rigid	Flexible						CTFE	PVF
Specific gravity g/cm^3	1,3 - 1,5	1,15 - 1,5	1,68	1,11 - 1,15	1,21 - 1,32	1,05 - 1,07	1,1 - 1,3	2,1	1,5
Water absorption % 24 hr. immersion	negligible	negligible	negligible	5 - 7	30 - 80	$<$0,06	-	<0,05	0,05
Moisture vapour permeability g/m^2 / 24 hr / mil thickness	3,9 - 79	9,0 - 125	1 - 4	0,25 - 242	>155	20 - 97	-	-	-
Tensile strength lb / sq. in.	5.500-10.000	1.000-5.600	7.000-15.000	3.500-6.000	3.000-10.000	7.000-12.100	9.000-13.000	5.000-8.000	7.000-18.000
Tear strength Elmendorf g / mil	10 - 700	13 - 1.400	30	60 - 1.600	55 - 800	2 - 8	-	10 - 26	12 - 100
Elongation %	2 - 25	50 - 500	20 - 40	200 - 800	200 - 800	3 - 10	200	50 - 150	115 - 250
Volume resistivity ohms-cm	5×10^{14} - 1×10^{15}	5×10^{8} - 5×10^{14}	10^{12} - 10^{16}	$1,5 \times 10^{13}$	-	10^{17} - 10^{19}	9.10^{16}-2.10^{17}	$>10^{18}$	$>10^{18}$
Surface resistivity ohms	10^{12} - 10^{13}	$>10^{14}$	-	-	2×10^{6}	10^{14}	-	-	-
Electric strength volts / mil	3.500	1.400-2.900	3.000-5.000	-	-	3.000-4.000	3.700 - 6.500	-	-
Power factor	8×10^{2} c/s 0,05 10^{3} c/s 0,02	8×10^{2} c/s 0,07 - 0,35 10^{3} c/s 0,1 - 0,128	50 c/s 0,03 - 0,45 10^{6} c/s 0,04 - 0,06	50 c/s 0,003 10^{6} c/s 0,006	-	60 - 10^{9} c/s 0,0003-0,0005	60 - 10^{6} c/s 0,000,2 - 0,000,6	-	-
Dielectric constant	10^{3} c/s 3,0 - 3,5	10^{3} c/s 4,5 - 8	50 c/s 4,5 - 6 10^{6} c/s 3,0 - 5	10^{3} c/s 3,51	10^{3} c/s >3	60 - 10^{9}c/s 2,6 - 2,7	60 - 10^{6} c/s 2,65	60 - 10^{6} c/s 2,1	160 - 10^{6} c/s 2,1
Softening heat sealing temperature °C	127 - 204	93 - 204	140	107 - 177	149 - 204	104 - 149	570 - 750 Melting point	300 - 390	225

Table 4. Thermosetting moulding materials

PROPERTY	Casein	Phenolics						Epoxides		Polyurethane
		Wood flour	Asbestos	Fibre and fabric	Mineral	Nylon	No filler cast resin	Glass	No filler cast resin	
Specific gravity g/cm^3	1,32 - 1,39	1,29 - 1,51	1,78 - 2,06	1,32 - 1,44	1,46 - 1,90	1,16 - 1,54	1,30 - 1,32	2,00 - 2,10	1,19 - 1,23	1,21
Water absorption %	3,0 - 8,0	0,7 - 1,2	0,03 - 0,3	0,5 - 1,6	0,04 - 0,25	0,25 - 0,4	0,3 - 0,4	0,02 - 0,08	0,07 - 0,14	0,3 - 0,9
Tensile strength lb/sq. in.	4.500-12.000	5.500-9.000	3.000-7.000	4.500-9.000	2.000-8.500	4.500-9.000	2.000- 9.000	6.000-10.000	8.000-12.000	6.400-8.600
Impact strength ft lb (izod per inch of notch)	1,0 - 1,8	0,20 - 0,52	0,16 - 3,0	0,38 - 6,60	0,18 - 0,72	0,26 - 0,52	0,50 - 0,80	5,0 - 8,0	0,72 - 1,38	>1,0
Modulus of elasticity 10^6 lb/sq. in.	0,55-0,60	0,7 - 2,0	1,6 - 2,9	0,8 - 1,4	1,35 - 3,0	0,4 - 2,0	0,2 - 0,45	2,0 - 2,5	0,14 - 0,66	0,47 - 1,2
Crushing strength lb/sq. in	27.000-58.000	20.000-40.000	17.000-30.000	20.000-42.000	14.000-35.000	15.000-40.000	6.700-15.000	20.000-25.000	13.000-18.400	-
Flexural strength lb/sq. in	10.000 - 18.000	8.500-13.500	6.500-11.000	7.000-16.000	8.000-12.000	6.000-13.000	12.000 - 15.000	13.000 - 19.000	10.000 - 18.500	-
Volume resistivity ohms - cm	$5,8 \times 10^9$ - $11,0 \times 10^9$	$10^9 - 10^{13}$	$10^8 - 10^{13}$	$10^8 - 10^{12}$	$10^{10} - 10^{14}$	$10^{11} - 10^{14}$	$2,5 \times 10^{10}$ - 10^{12}	$> 10^{14}$	$5,9 \times 10^{14}$ - $8,7 \times 10^{14}$	6×10^{12} - 10^{14}
Surface resistivity ohms	$3,2 \times 10^{10}$ - $8,0 \times 10^{10}$	10^8 - 5×10^{13}	5×10^7 - 10^{13}	5×10^6 - 10^{12}	$10^{10} - 10^{14}$	$10^{11} - 10^{14}$	10^{10} - 5×10^{10}	$> 10^{14}$	$3,8 \times 10^7$ - $> 10^{14}$	6×10^{13} - 3×10^{15}
Electric strength volts / mil	216 - 700	15 - 250	10 - 250	10 - 180	75 - 400	30 - 275	250 - 400	250 - 350	36 - 500	500
Power factor at 10^6 cycles/sec	0,052-0,06	0,015-0,06	0,03 - 0,25	0,03 - 0,08	0,007-0,08	0,15 - 0,2	0,04 - 0,05	0,010-0,020	0,015-0,048	0,03 - 0,048
Dielectric constant at 10^6 cycles / sec	6,1 - 6,8	3,9 - 6,5	5,0 - 6,0	4,8 - 7,0	4,0 - 6,0	3,7 - 4,5	10^3 c/s 4,0 - 9,7	4,0 - 5,5	3,3 - 6,2	3,3 - 3,9
Softening point °C		149 - 200	177 - 210	149 - 170	121 - 149	140 - 160	116 - 127	140 - 200	123 - 288	150 - 185

Table 4. Thermosetting moulding materials

PROPERTY	Silicones	Aminos				Polyesters or alkyds			
		Ureas		Melamines					
	Glass	Wood flour	α-cellulose	Cellulose	Mineral	α-cellulose	Mineral	Glass filled	No filler cast resin
Specific gravity g/cm3	1,80 - 1,90	1,50 - 1,60	1,50 - 1,60	1,50 - 1,60	1,80	1,35 - 1,40	1,70 - 2,23	1,2 - 2,0	1,20 - 1,40
Water absorption %	0,16	0,7	0,4 - 0,8	0,3 - 0,5	0,10 - 0,20	0,01 - 1,0	-	0,1 - 2	0,03 - 0,4
Tensile strength lb/sq. in.	2.400-3.000	7.500-14.000	7.500-11.500	8.000-12.000	4.000-6.000	6.000-7.500	3.000-6.500	6.000-10.000	5.000-13.000
Impact strength ft lb (izod per inch of notch)	0,6 - 4,5	0,16 - 0,33	0,18 - 0,34	0,15 - 0,25	0,12 - 0,22	0,34 - 0,44	0,12 - 0,70	7 - 10	0,38 - 2,0
Modulus of elasticity 10^6 lb/sq. in.		0,90 - 1,0	0,95 - 1,0	1,3	1,6	-	1,4 - 2,7	0,6 - 1,7	0,4 - 0,65
Crushing strength lb/sq. in	9.000-15.000	29.000-36.000	28.000-35.000	25.000-43.000	30.000	-	18.000-28.000	15.000-28.000	18.[illegible]-[illegible].000
Flexural strength lb/sq. in	12.000 - 16.000	11.800 - 19.000	11.800 - 17.000	10.000 - 21.000	6.000-11.000	10.000 - 12.000	2.500-9.000	12.000 - 21.000	6.500-13.000
Volume resistivity ohms - cm	$>10^{12}$	5×10^{11} - 10^{14}	5×10^{11} - 10^{14}	$>10^{13}$	10^{13} - 10^{14}	$>10^{14}$	$>10^{14}$	10^{12} - 10^{15}	$2,7 \times 10^{14}$ - 2×10^{15}
Surface resistivity ohms	—	10^{11} - 10^{14}	10^{11} - 10^{14}	10^{12} - 10^{14}	10^{12} - 10^{14}	10^{9} - $>10^{14}$	$>10^{11}$	10^{10} - 10^{14}	10^{13} - $9,14^{13}$
Electric strength volts / mil	>100	20 - [illegible]80	20 - 240	70 - 240	130 - 250	250 - 350	250 - 430	150 - 350	245 - 420
Power factor at 10^6 cycles/sec	0,004-0,0065	8×10^2 c/s 0,05-0,1	8×10^2 c/s 0,04 - 0,8	0,027-0,045	0,035-0,055	8×10^2 c/s 0,02 - 0,05	0,013-0,04	1,1 - 0,04	0,01 - 0,03
Dielectric constant at 10^6 cycles/sec	up to 5	8×10^2 c/s 8 - 10	8×10^2 c/s 7 - 9	7,2 - 8,2	4,7 - 7,0	3,5 - 5,5	4,5 - 7,0	4,5 - 6,0	3,0 - 4,01
Softening point °C	[illegible]	70 - 60	70 - 80	[illegible]0 - 100	140 - 150	-	149 - 177	149 - 177	121

Table 5. Thermoset laminated sheets

PROPERTY	Phenolics					Aminos	Polyesters		Silicones	Epoxides
	Paper	Fabric	Asbestos Fabric	Glass Mat	Glass Fabric	Melamine Glass Fabric	Glass Mat	Glass Fabric	Glass Fabric	Glass Fabric
Specific gravity g/cm^3	1,3 - 1,4	1,3 - 1,4	1,63	1,4 - 1,7	1,7 - 1,8	1,7 - 1,8	1,5 - 1,8	1,7 - 2,1	1,7 - 1,9	1,7 - 1,8
Tensile strength lb/sq in	8.000-23.000	8.000-19.000	6.000-12.000	15.000-25.000	18.000-35.000	23.000-40.000	10.000-30.000	15.000-52.000	8.000-25.000	30.000-95.000
Flexural strength lb/sq in	14.000-30.000	16.000-30.000	12.000	25.000-40.000	18.000-45.000	17.000-21.000	15.000-32.000	27.000-60.000	11.000-35.000	42.000-100.000
Shear strength lb/sq in	[illegible].500-16.500	9.000-16.000	10.000	-	-	21.000	12.000	10.000-20.000	13.000-15.000	-
Impact strength edgewise ft lb	0,14 - 1,6	0,65 - 4,0	15 - 24	12 - 20	7 - 12	5 - 10	10 - 20	6 - 20	5 - 12	12 - 18
Water absorption mgms (on specimen $1\frac{1}{2} x 1\frac{1}{2} x \frac{1}{8}$ in)	5 - 260	15 - 135	25 - 190	40 - 100	55 - 165	15 - 120	< 85	< 100	11 - 45	5 - 10
Insulation resistance 24 hr in water ohms	6×10^6 - 9×10^{11}	3×10^6 - 6×10^9	$0,5 \times 10^6$	> 10	5×10^6 - $> 10^8$	$2 \times 10^8 - 10^9$	$5 \times 10^5 - 10^6$	$5 \times 10^6 - 10^9$	$4,5 \times 10^9$ - 2×10^{10}	$0,5 \times 10^6$ - 3×10^{10}
Insulation resistance 48 hr. at 75% R.H. ohms	6×10^9 - 2×10^{12}	-	-	$> 4 \times 10^{12}$	$1,5 \times 10^{12}$ - 2×10^{12}	1×10^{12} - 2×10^{12}	2×10^{12} - 5×10^{12}	2×10^{12} - 5×10^{12}	10^{12}	-
Electrical strength flatwise at 90°C volts/mil	70 - 1.000	25 - 200	10 - 15	-	100 - 450	120 - 500	200 - 250	135 - 350	130 - 450	300 - 500
Electrical strength edgewise at 90°C volts/mil	15 - 50	4 - 14	1	-	-	32	37,3	-	35 - 40	40 - 45
Power factor at 10^6 cycles/sec	0,03 - 0,056	0,05 - 0,1	0,06 - 0,1	0,02 - 0,025	0,01-0,085	0,01 - 0,02	0,023	0,003 - 0,05	0,003 - 0,022	0,01 - 0,035
Dielectric constant at 10^6 cycles/sec	4 - 6	5,0 - 6,5	5,5 - 10,0	3,9 - 4,4	4,0 - 5,6	4,2 - 6,5	2,6	3,5 - 5,6	3,5 - 4,5	4,2 - 5,3
Percentage yield under compression	1,2 - 4,0	1,6 - 2,5	2,4	-	-	-	1,35 - 2,0	0,73 - 1,7	1,7 - 2,5	-
Recommanded max working temperature °C	93 - 121	107 - 121	135	-	135 - 14[illegible]	149 - 1[illegible]0			[illegible] - 250	[illegible]

PLASTICS SELECTION TABLES (GENERAL BIBLIOGRAPHY P 119)

TABLE 6 : PLASTICS FOR MECHANICAL APPLICATIONS

A. Heavily stressed mechanical components - Cams, Gears, Couplings, Racks, Rollers etc.

Properties required

- High impact strength
- High tensile strength
- Good fatigue resistance
- Excellent machinability or mouldable to close tolerance
- Stability at elevated temperatures.

Types of plastics with particular application

Acetals are recommended for:

- maximum fatigue life
- highly accurate parts
- exposure to extremely humid and corrosive conditions.

Epoxies for ultimate high tensile applications.

Fluorocarbons (P.T.F.E. filled acetals) for duty applications.

Nylons for general purpose gears and other mechanical components.

Phenolics (fabric filled) for thin stamped gears or parts.

B. Materials for low friction applications - Bearings, Bushings, Guides, Impellers, Slides, Valve, Valve liners, Wearing surfaces etc.

Properties required

- High resistance to abrasion
- Low friction co-efficient
- Heat resistance
- Corrosion resistance
- Good form stability.

Types of plastics with particular application

- Acetals for:- submerged (water or organic solvents) or humid service when resistance to creep is important.

  - for valve liners or slides to eliminate jerky starts.

- Fluorocarbons (especially P.T.F.E.) for:
  - sliding or low speed rotating dry bearings
  - highly corrosive service
  - service in extreme temperatures (-200 to + 260°C)
  - non-stick surfaces.

- Fluorocarbons (filled) for:
  - heavy loadings and
  - high creep resistance

- Nylon for general purpose bearings and wear surfaces.

- Polyethylene (high density) at very low speeds and loads.

TABLE 7 : PLASTICS FOR ELECTROSTRUCTURAL PARTS

Properties required

- Excellent electrical resistance in low to medium frequencies.
- High tensile - and impact strength
- Good fatigue resistance
- Good dimensional stability and excellent moulding characteristics

Types of plastics with particular application

- Alkyds, Aminos and Polyesters are recommended for general electrical components.
- Epoxies: Potting and encapsulation of electronic components for maximum environmental resistance.
  - excellent dimensional stability over wide temperature ranges.
- Melamines for:
  - hardness
  - high shock resistance and
  - high resistance to burning
- Phenolics for punched and stamped parts
- Polycarbonates for transparent parts requiring high impact strength.
- Silicones for very high heat resistance.

NOTE:-

Polystyrene and teflon have excellent electrical properties in high frequency applications.

Iono ers, polyvinylchloride and polyethylene are recommended in high voltage applications.

TABLE 8 : PLASTICS FOR GENERAL APPLICATIONS

A. For thermal and chemical equipment, plating components etc.

Properties required

- Resistance to very high temperatures
- Resistance to a wide range of chemicals
- Minimum moisture absorption
- Good mechanical properties

Types of plastics with particular application

- Epoxy for greatest mechanical strength
- Fluorocarbons
  - a) P.T.F.E. for:
    - general chemical purposes
    - extreme temperature applications
  - b) P.C.T.F.E. for transparency
  - c) P.V.F. and P.C.T.F.E. for extreme chemical resistance combined with mechanical strength and stiffness.
- Polypropylene - Polyethylene (high density) for plating and less severe chemical exposures.

NOTE:-

Polyvinylchloride has good chemical resistance but is not temperature resistant.

B. Materials for Containers, Ducts etc.

Properties required

- Good impact strength and stiffness
- Good formability and mouldability characteristics
- Good environmental resistance
- Good mechanical properties and dimensional stability.

Types of plastics with particular application

- ABS recommended for general applications
- Polyesters (glass-filled) and epoxies (glass-filled) for:
    - maximum strength to weight ratios
    - stiffness
    - heat resistance
- Polypropylene, polyethylene (high density) and epoxy (glass-filled) for applications in corrosive environments. Polypropylene has also a high flexing strength.

C. Plastics for Light - transmission Components, Models, etc.

Properties required

- good light transmission
- excellent formability and mouldability
- shatter resistance
- fair to good mechanical properties

Types of plastics with particular application

- Acrylics and Polystyrenes recommended for general purpose applications, especially for optical use.
- Acrylics have also excellent low temperature properties.
- Cellulose acetates and Vinyls for - flexible glazing
  - guards
- Cellulose butyrates for - excellent impact resistance
  - deep formability
- Ionomers for - excellent clarity
- Polycarbonates for - maximum strength
- Vinyls for - maximum formability
  - printability

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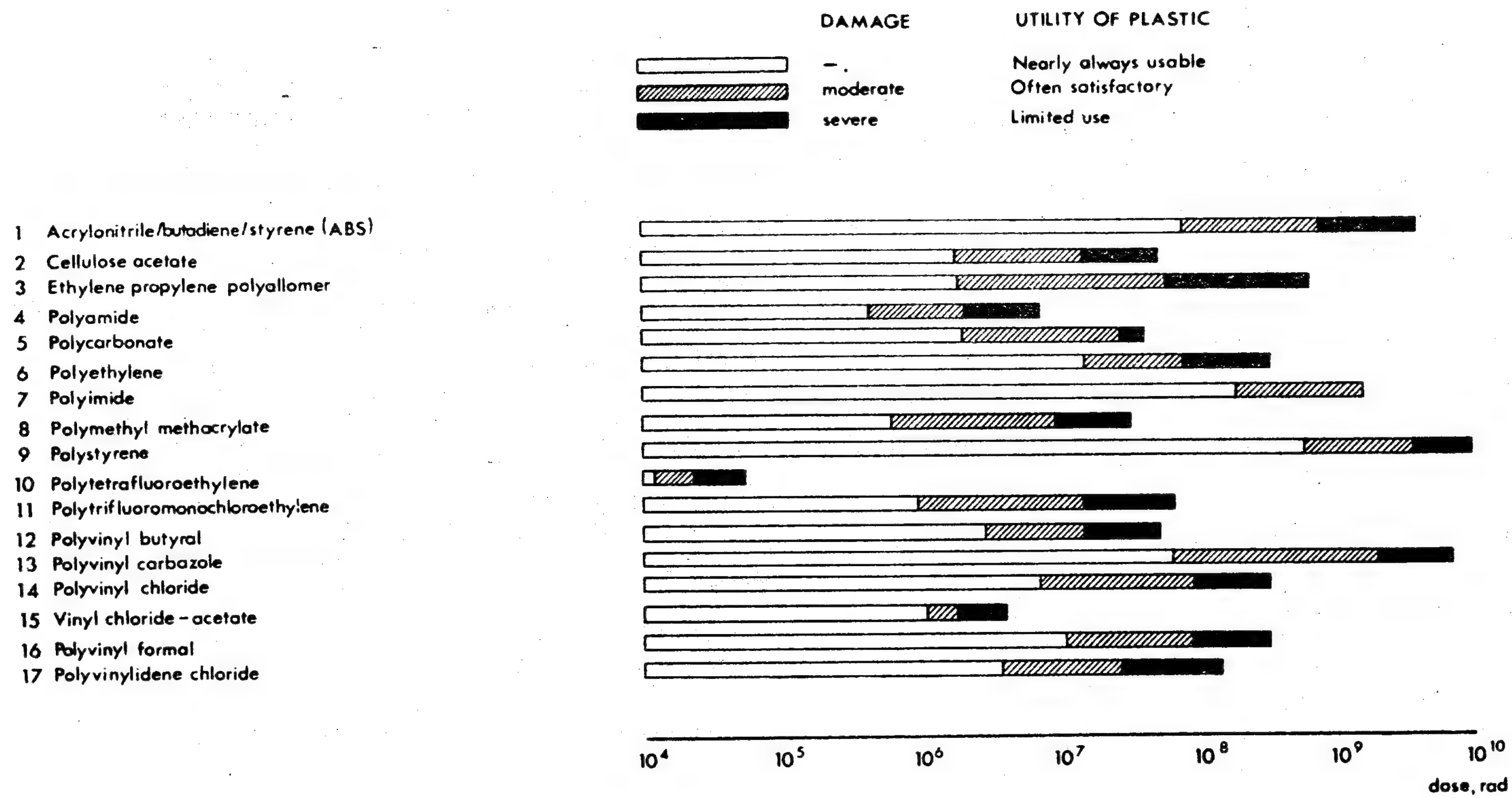


Fig. 1 RELATIVE RADIATION RESISTANCE OF THERMOPLASTIC RESINS (2,3,4,5)

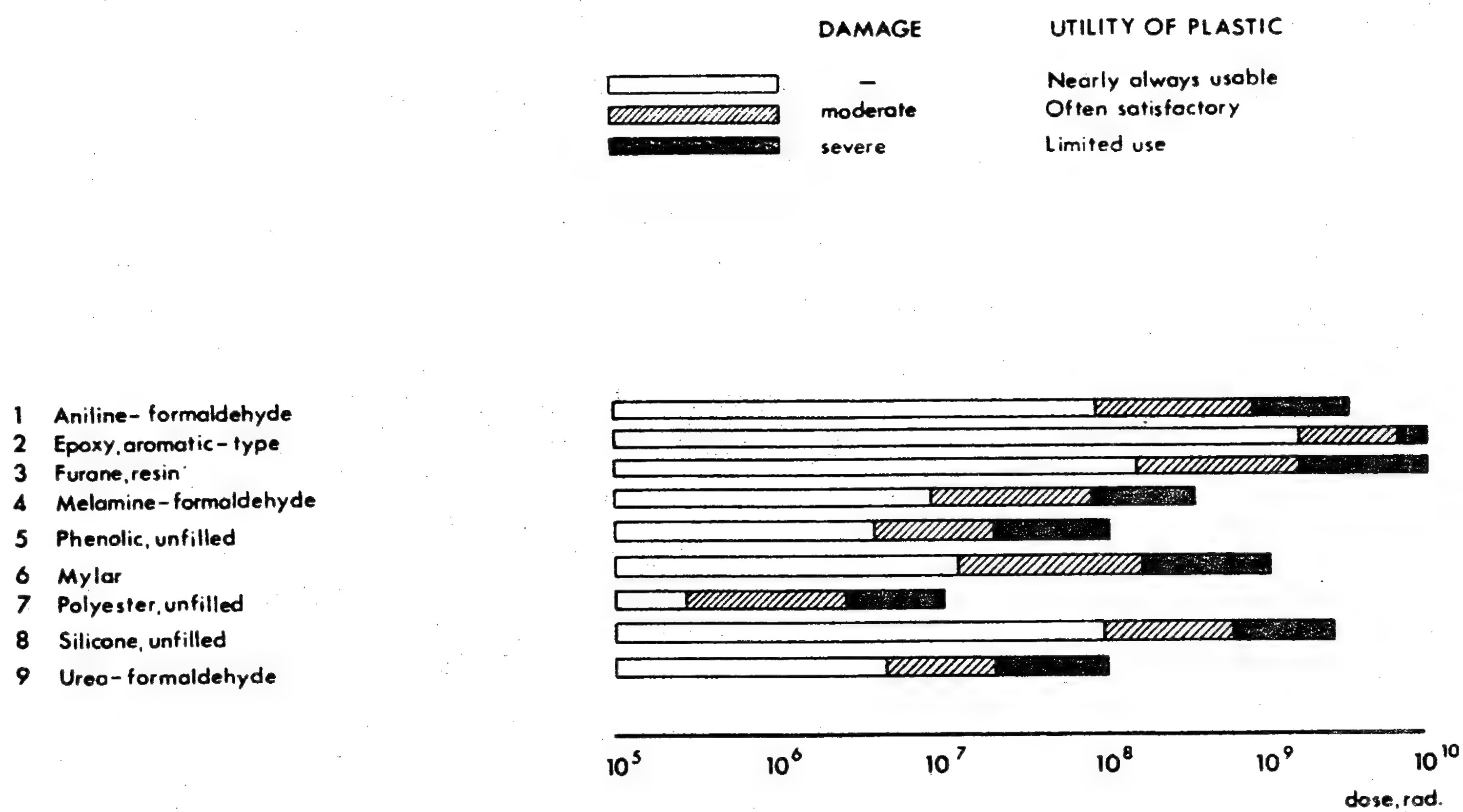
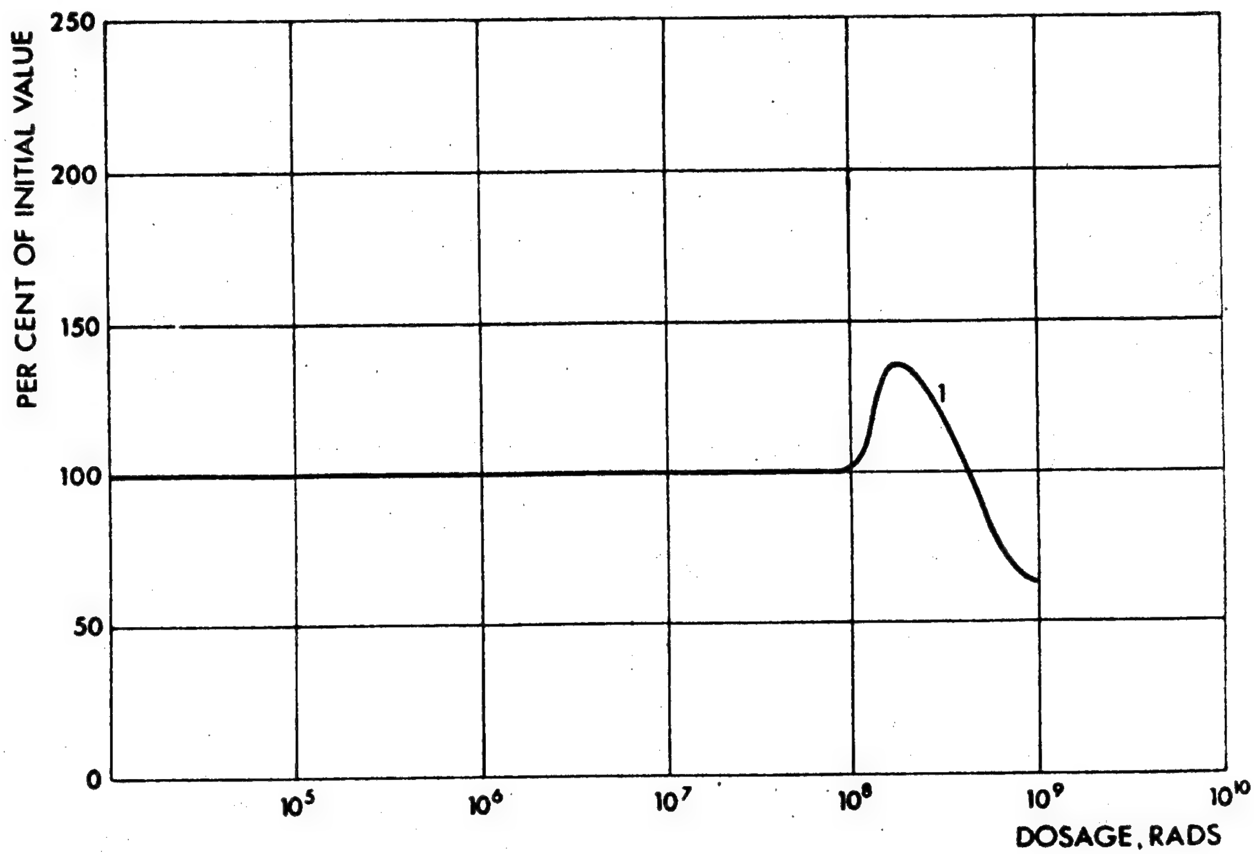


Fig. 2 RELATIVE RADIATION STABILITY OF THERMOSETTING RESINS (2,3,4,5)

Effect of radiation on mechanical properties

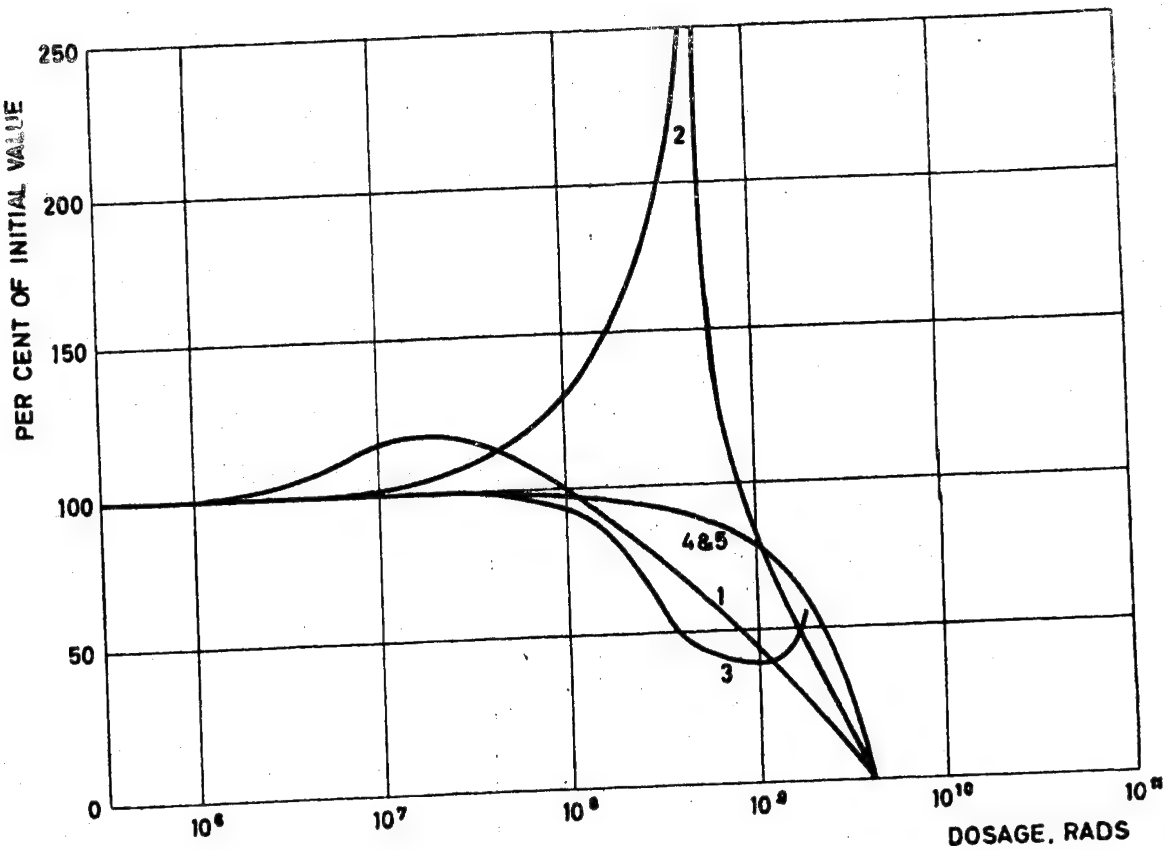


CURVE Nº	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	3.730 PSI
2	ELONGATION	–
3	ELASTIC MODULUS	–
4	SHEAR STRENGTH	–
5	IMPACT STRENGTH	–

Fig. 3 ABS (ACRYLONITRILE-BUTADIENE-STYRENE, TERPOLYMER)

" KRALASTIC MV " (6)

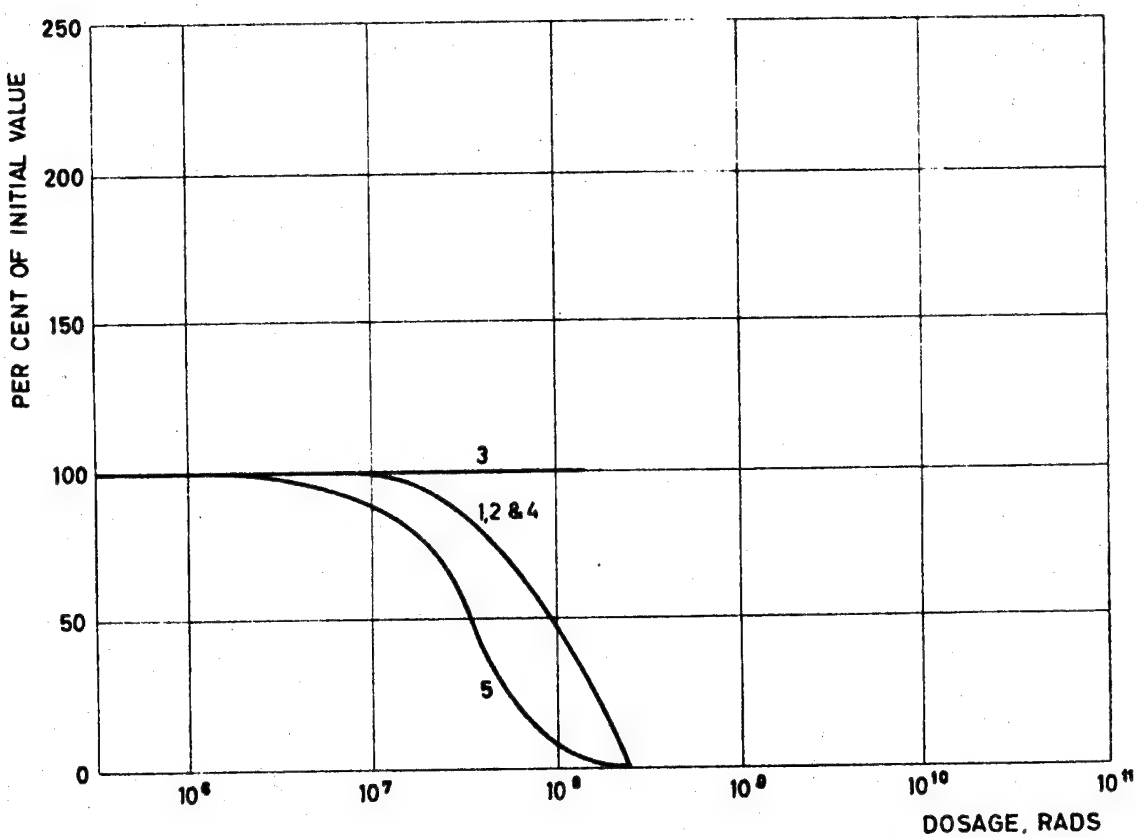
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	6,700 PSI
2	ELONGATION	2.4 %
3	ELASTIC MODULUS	2.8×10^5 PSI
4	SHEAR STRENGTH	5,000 PSI
5	IMPACT STRENGTH	0.35 FT-LB/IN. OF NOTCH

Fig. 4 Allyl diglycol carbonate - "CR-39" (7,8,9,10,11)

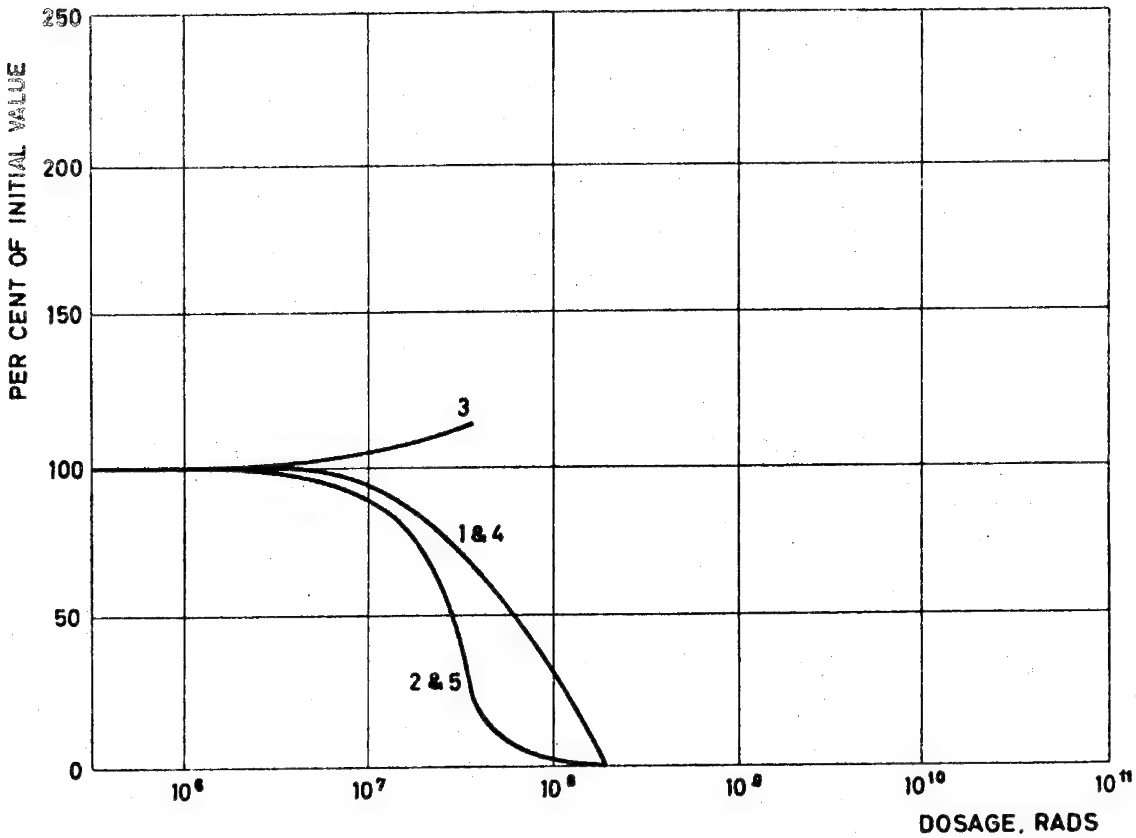
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	8,500 PSI
2	ELONGATION	2.0 %
3	ELASTIC MODULUS	5.7×10^5 PSI
4	SHEAR STRENGTH	9,800 PSI
5	IMPACT STRENGTH	0.50 FT-LB/IN. OF NOTCH

Fig. 5 Casein - "Ameroid" (7,8,11,12)

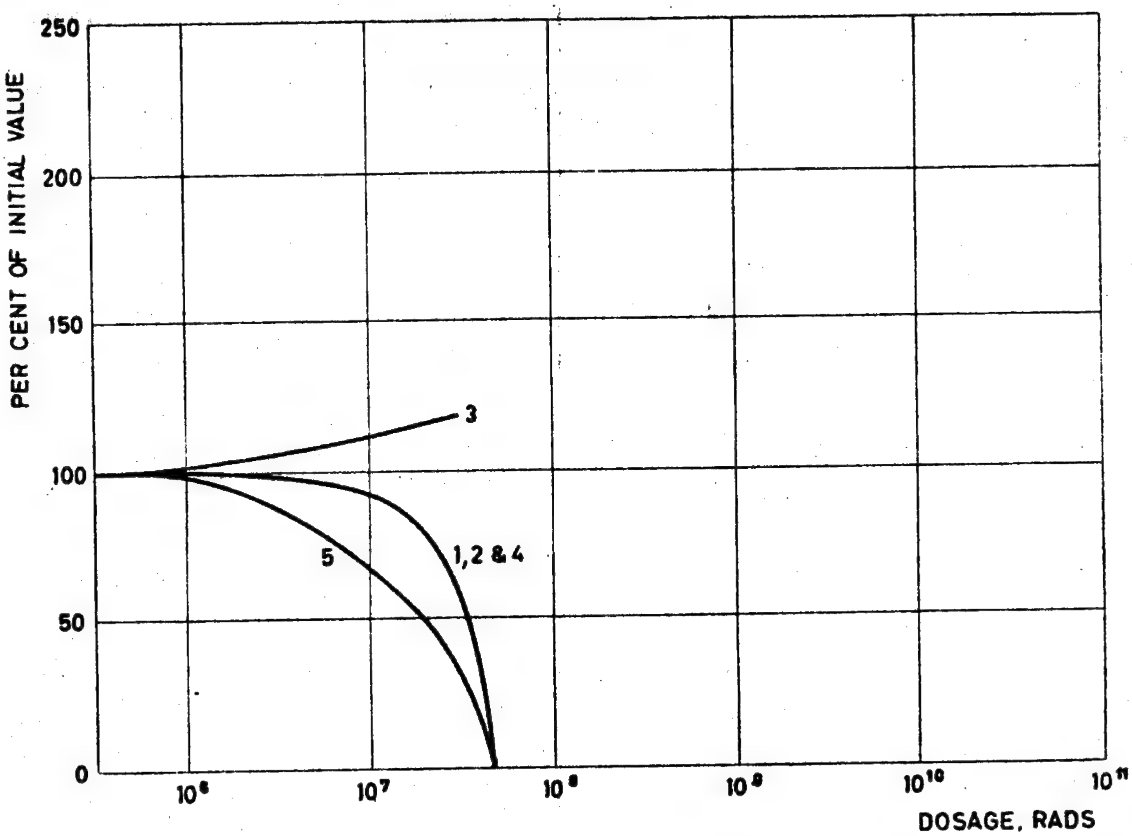
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	5,300 PSI
2	ELONGATION	20 %
3	ELASTIC MODULUS	2.6×10^5 PSI
4	SHEAR STRENGTH	6,400 PSI
5	IMPACT STRENGTH	1.37 FT-LB/IN. OF NOTCH

Fig.6 Cellulose acetate – "Plastacele" (7,8,11,12,13)

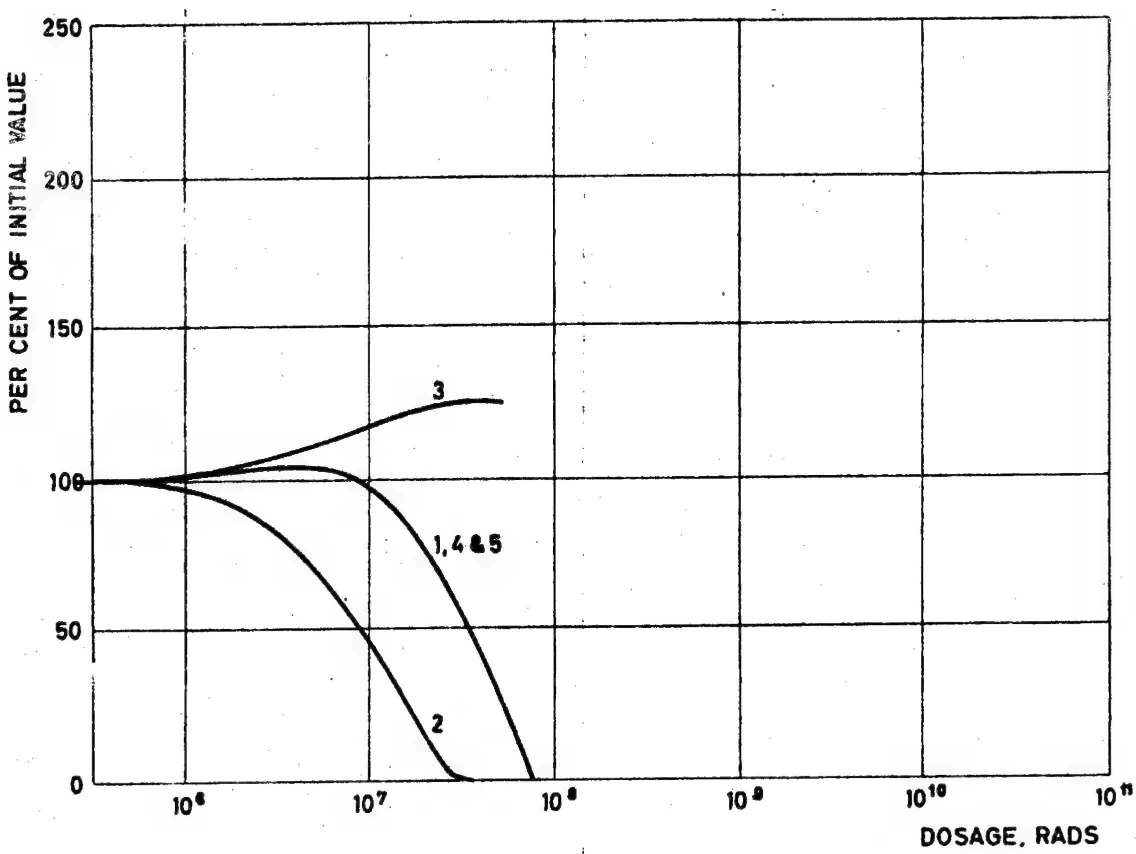
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	4,200 PSI
2	ELONGATION	60 %
3	ELASTIC MODULUS	$1{,}6 \times 10^5$ PSI
4	SHEAR STRENGTH	4,000 PSI
5	IMPACT STRENGTH	3,3 FT-LB/IN. OF NOTCH

Fig. 7 Cellulose acetate butyrate - "Tenite butyrate" (7,8,11, 14)

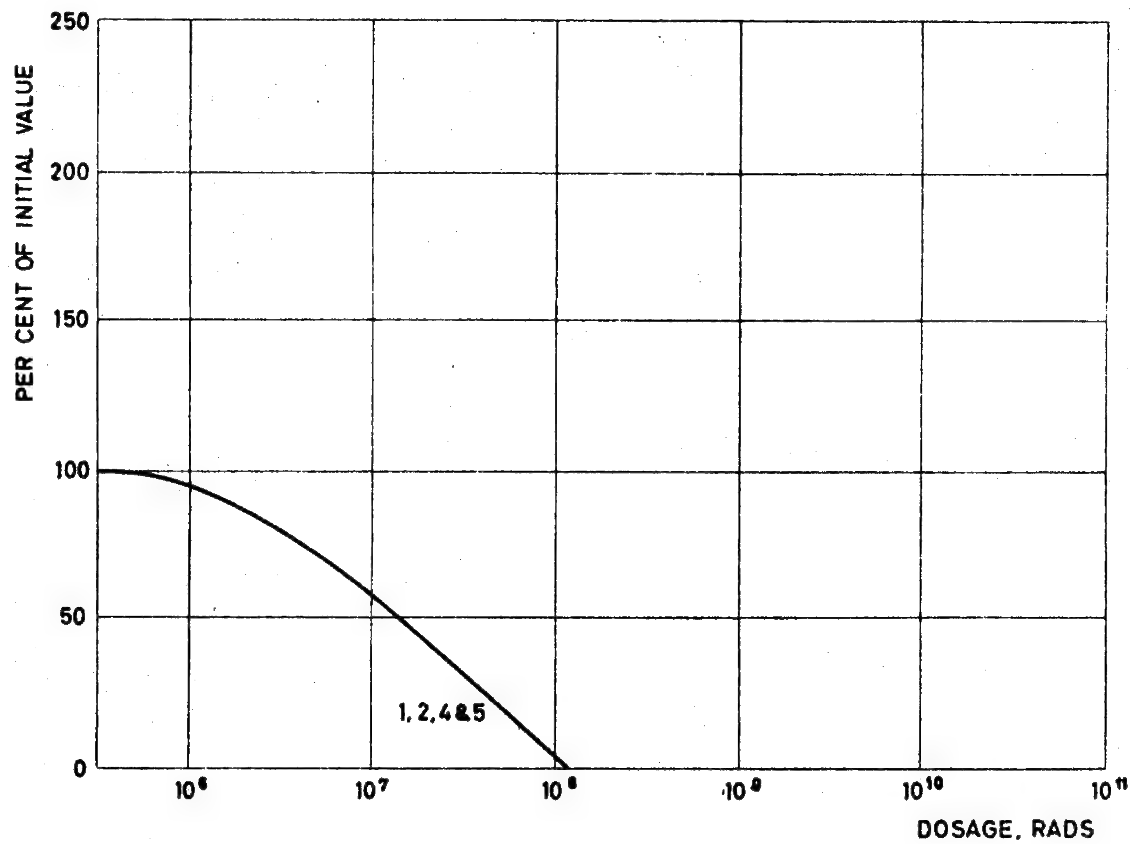
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	7,600 PSI
2	ELONGATION	30 %
3	ELASTIC MODULUS	3.6×10^5 PSI
4	SHEAR STRENGTH	8,800 PSI
5	IMPACT STRENGTH	2.75 FT-LB / IN. OF NOTCH

Fig. 8 Cellulose nitrate - "Pyralin" (7,8,11,12)

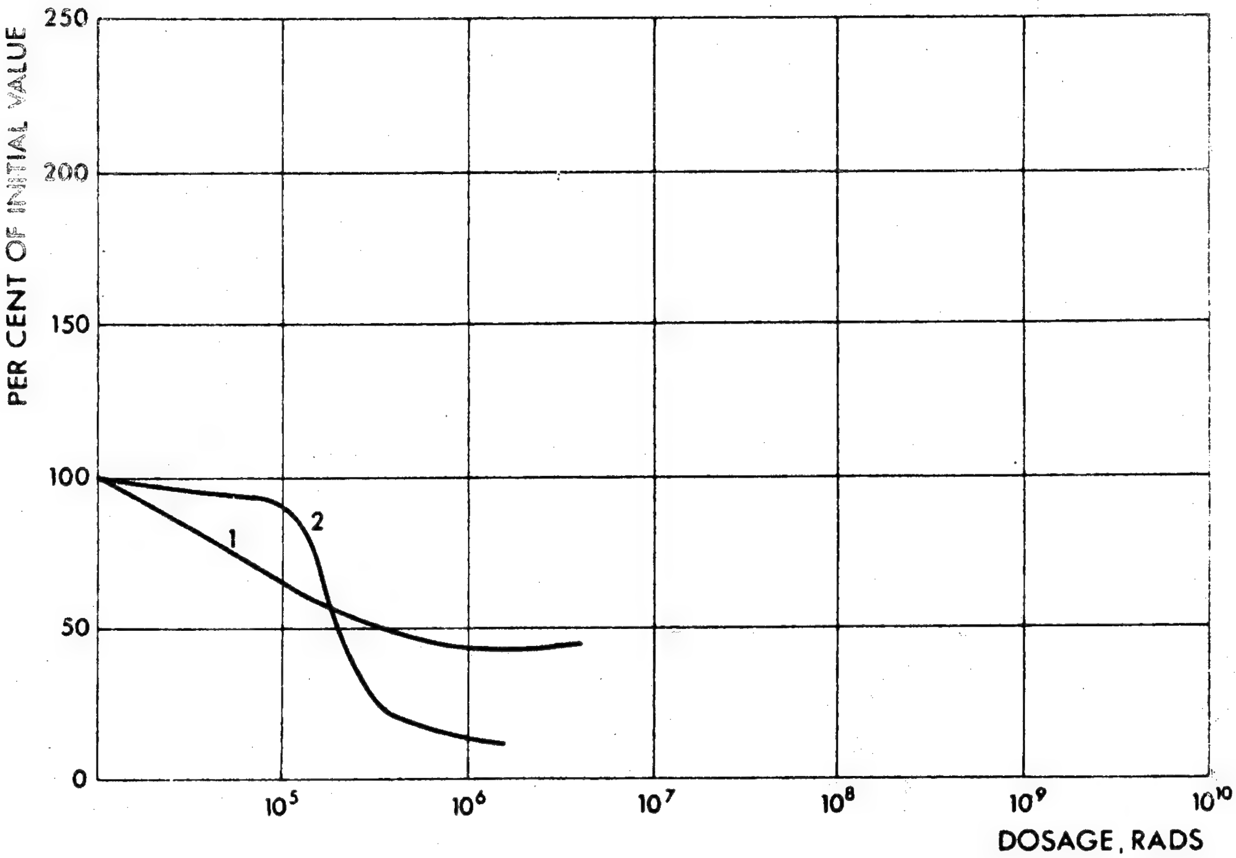
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	2,600 PSI
2	ELONGATION	1,6 %
3	ELASTIC MODULUS	—
4	SHEAR STRENGTH	2900 PSI
5	IMPACT STRENGTH	1,1 FT-LB/IN. OF NOTCH

Fig. 9 Cellulose propionate - "Tenite propionate" (7,8,11,12)

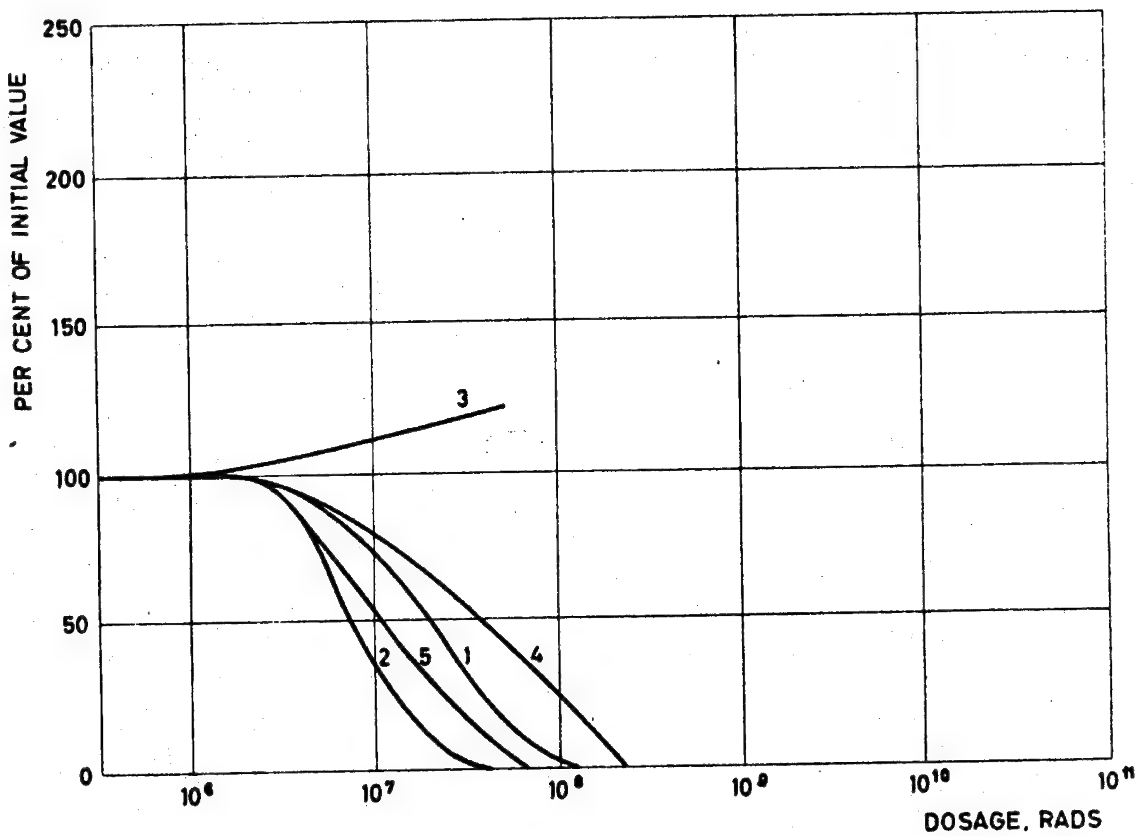
Effect of radiation on mechanical properties



CURVE Nº	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	3.000 PSI
2	ELONGATION	165%
3	ELASTIC MODULUS	—
4	SHEAR STRENGTH	—
5	IMPACT STRENGTH	—

Fig. 10 COPOLYMER OF HEXAFLUOROPRENE AND TETRAFLUOROETHYLENE: TEFLON FEP 100 (15)

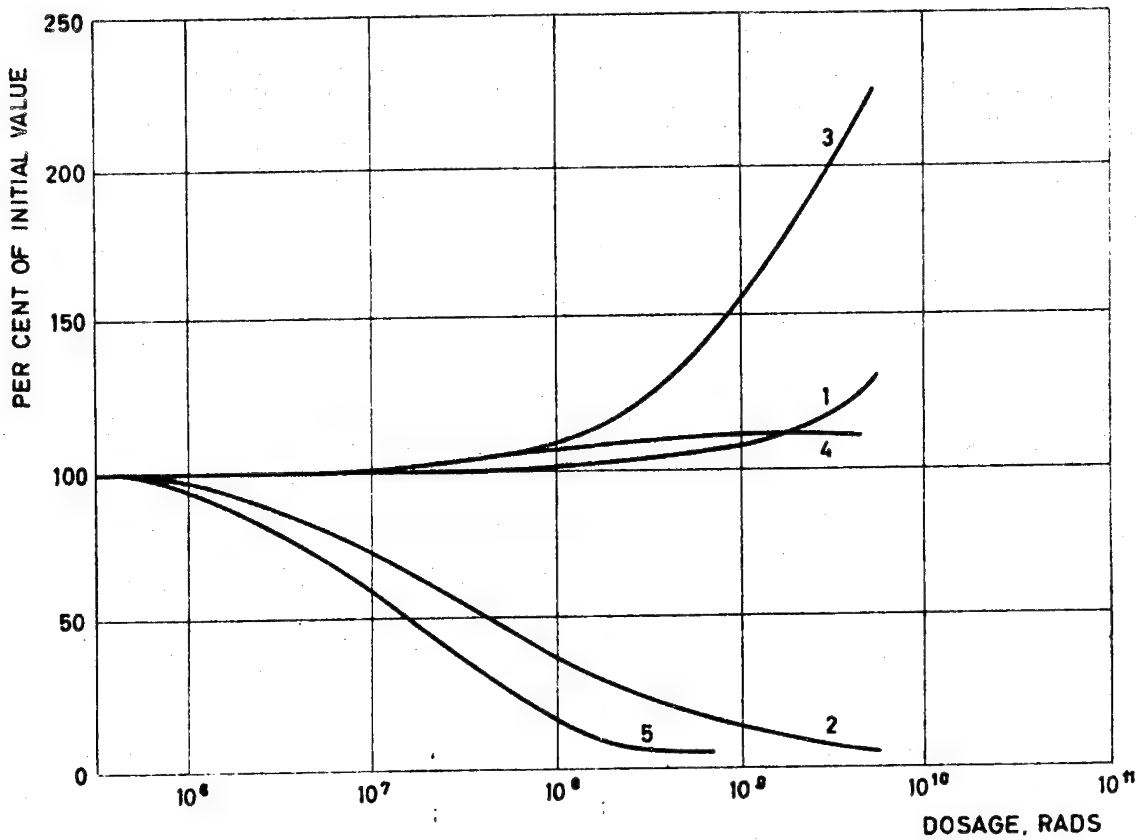
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	6,000 PSI
2	ELONGATION	40 %
3	ELASTIC MODULUS	2.1×10^5 PSI
4	SHEAR STRENGTH	6,700 PSI
5	IMPACT STRENGTH	2.0 FT-LB/IN. OF NOTCH

Fig. 11 Ethyl cellulose - "Ethocel" (7,8,11,12)

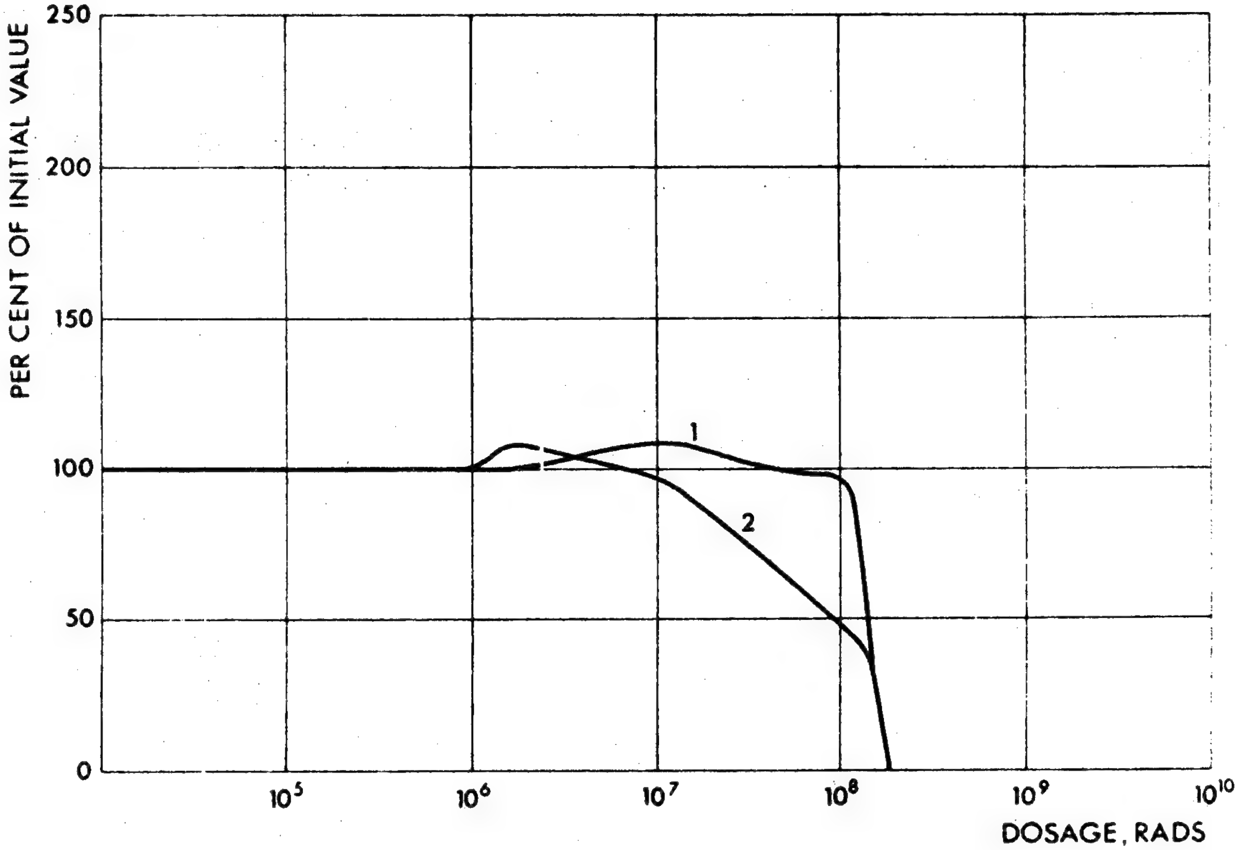
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	7,600 PSI
2	ELONGATION	62 %
3	ELASTIC MODULUS	2.0×10^5 PSI
4	SHEAR STRENGTH	7,300 PSI
5	IMPACT STRENGTH	2.8 FT-LB/IN. OF NOTCH

Fig. 12 Polyamide "Nylon" (7, 8, 11, 16, 17)

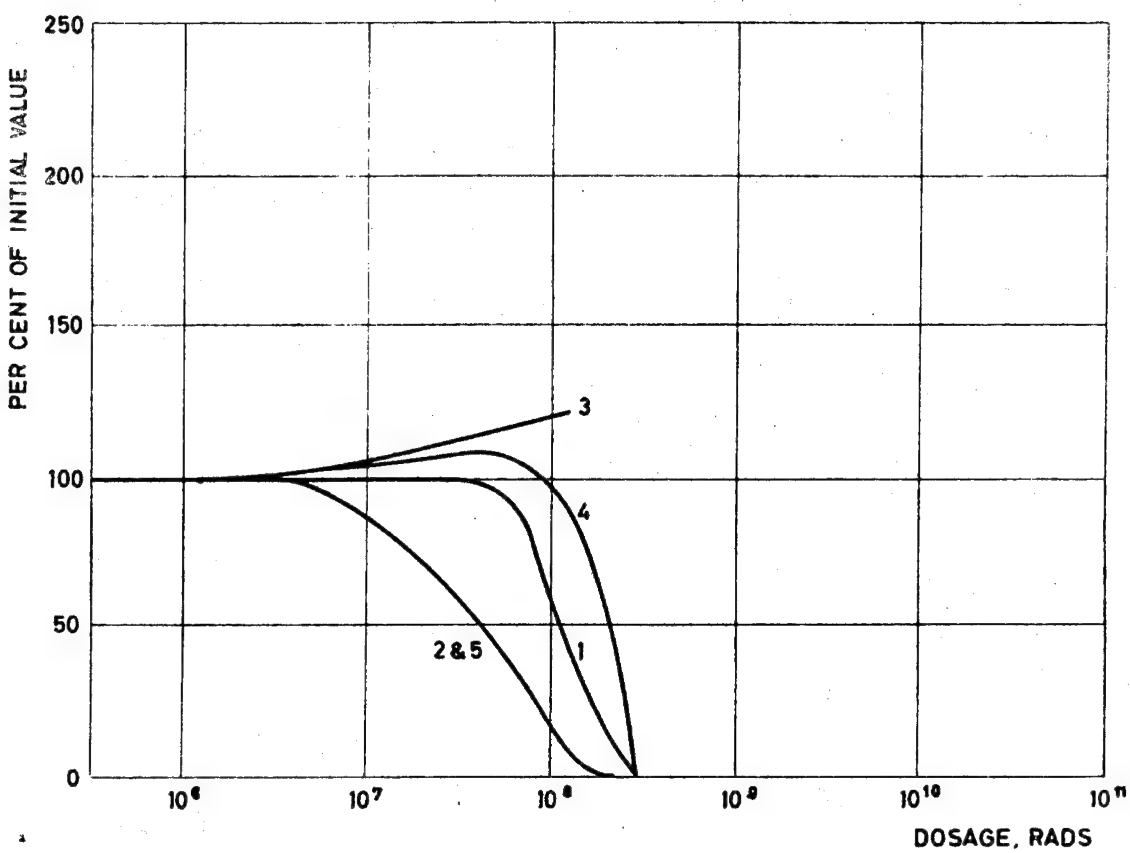
Effect of radiation on mechanical properties



CURVE N°	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	6.200 PSI
2	ELONGATION	96 %
3	ELASTIC MODULUS	—
4	SHEAR STRENGTH	—
5	IMPACT STRENGTH	—

Fig. 13 POLYCARBONATE "LEXAN FILM" (18,11,20)

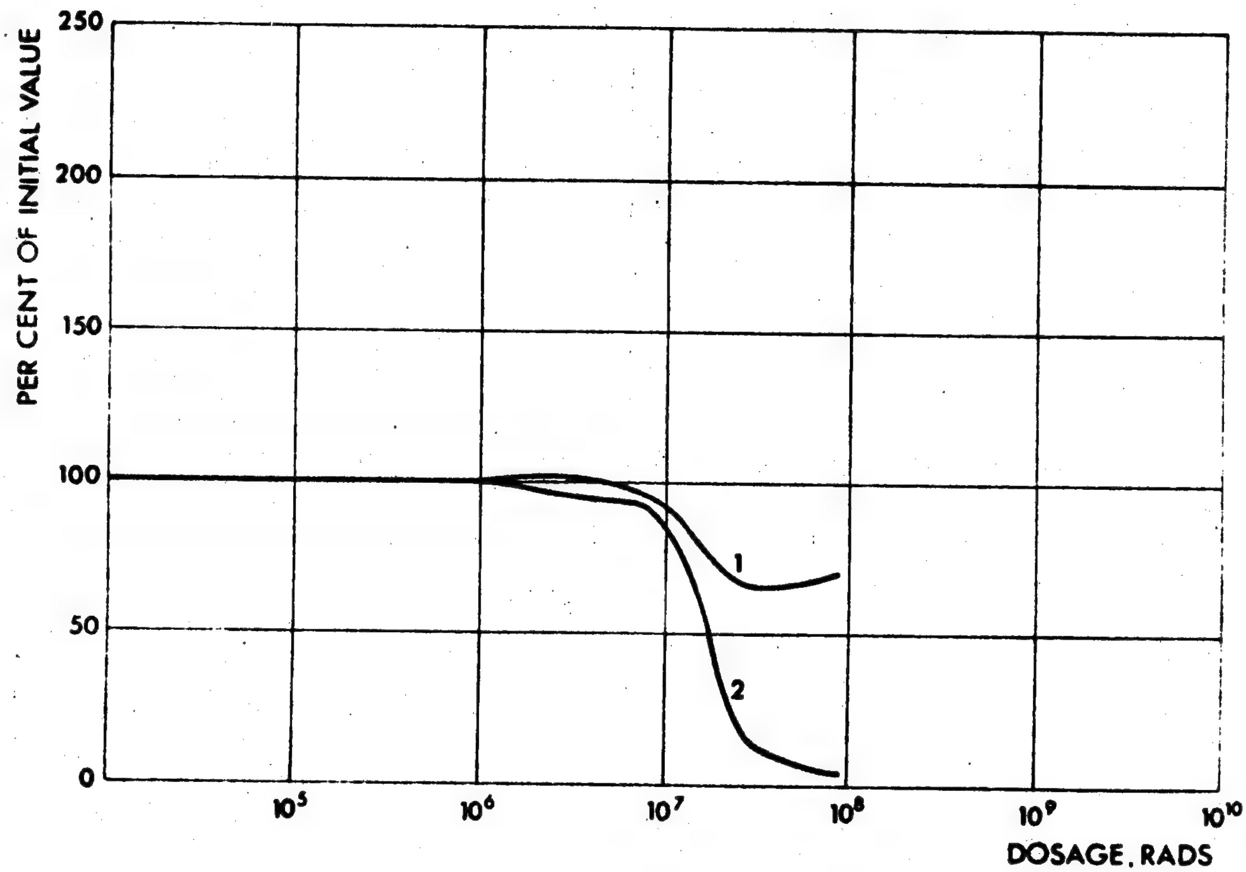
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	4,900 PSI
2	ELONGATION	50 %
3	ELASTIC MODULUS	$1{,}8 \times 10^5$ PSI
4	SHEAR STRENGTH	5,300 PSI
5	IMPACT STRENGTH	1,9 FT-LB/IN. OF NOTCH

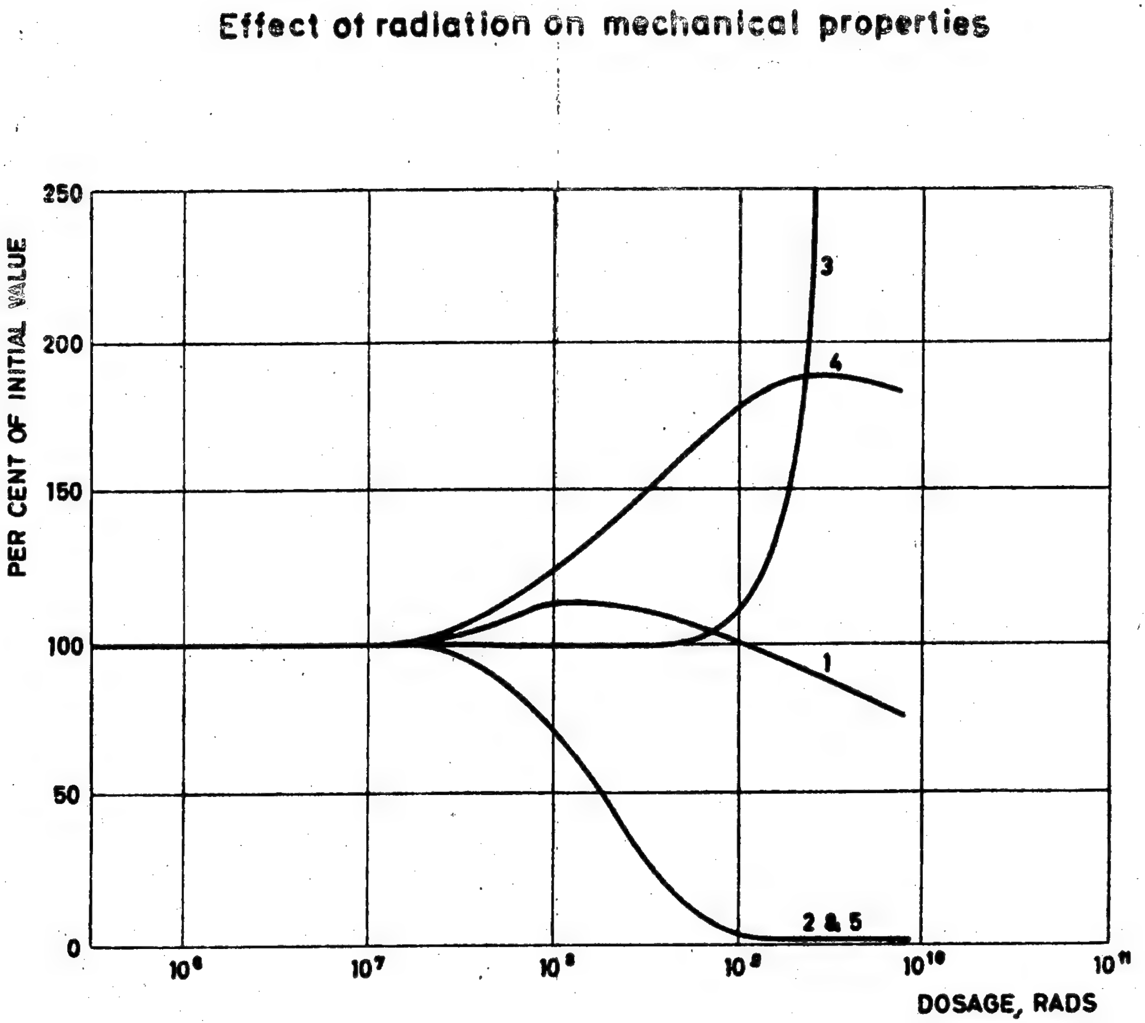
Fig. 14 Polychlorotrifluoroethylene - "Fluorothene" (7,8,11,21,22)

Effect of radiation on mechanical properties



CURVE Nº	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	1.915 PSI
2	ELONGATION	38%
3	ELASTIC MODULUS	—
4	SHEAR STRENGTH	—
5	IMPACT STRENGTH	—

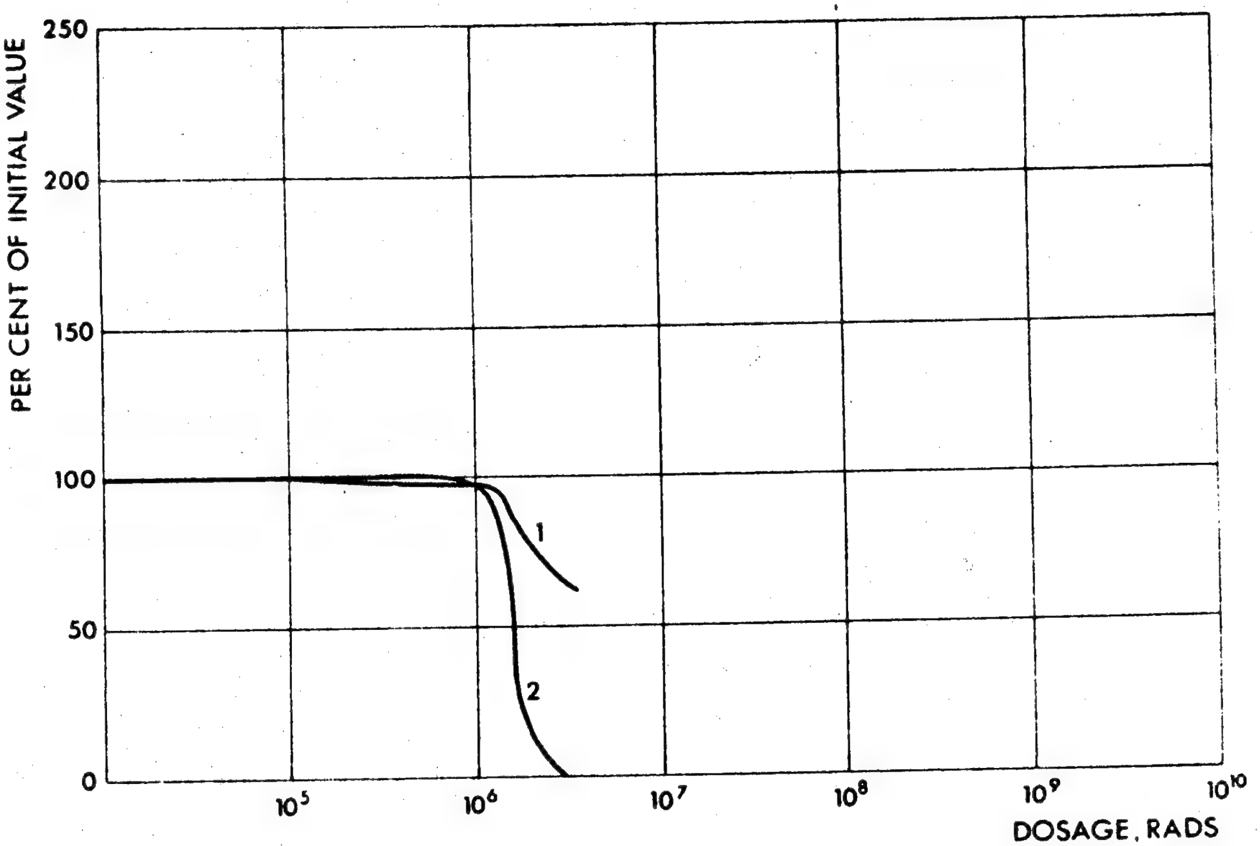
Fig. 15 POLYETHYLENE "ALATHON 3, NC-10FILM" (20)



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	1400 PSI
2	ELONGATION	250 %
3	ELASTIC MODULUS	0.30×10^5 PSI
4	SHEAR STRENGTH	1400 PSI
5	IMPACT STRENGTH	11.2 FT-LB / IN. OF NOTCH

Fig. 16 Polyethylene "Polythene" (7,8,11,23,24,25,26,27,28)

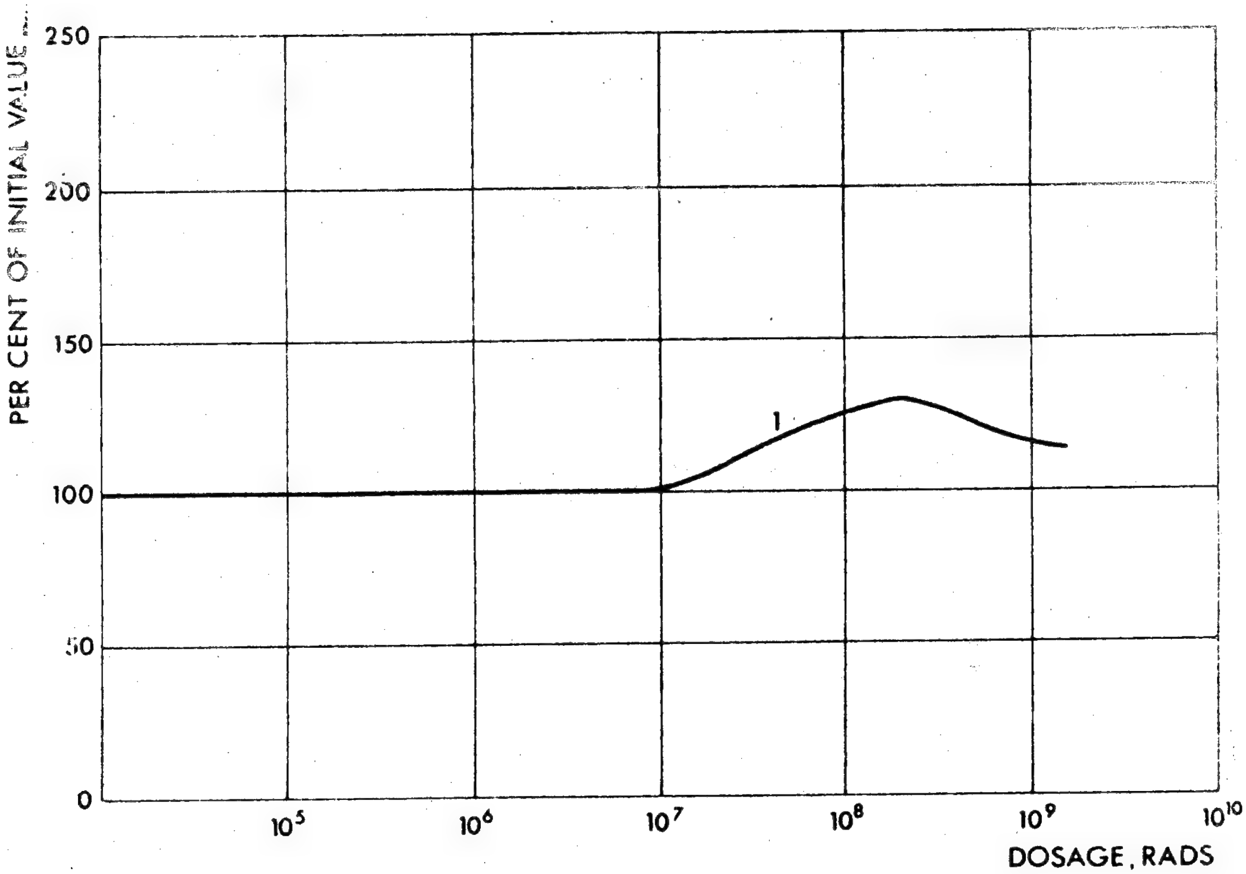
Effect of radiation on mechanical properties



CURVE Nº	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	10.450 PSI
2	ELONGATION	70%
3	ELASTIC MODULUS	—
4	SHEAR STRENGTH	—
5	IMPACT STRENGTH	—

Fig. 17 POLYFORMALDEHYDE "DELRIN" (12, 29)

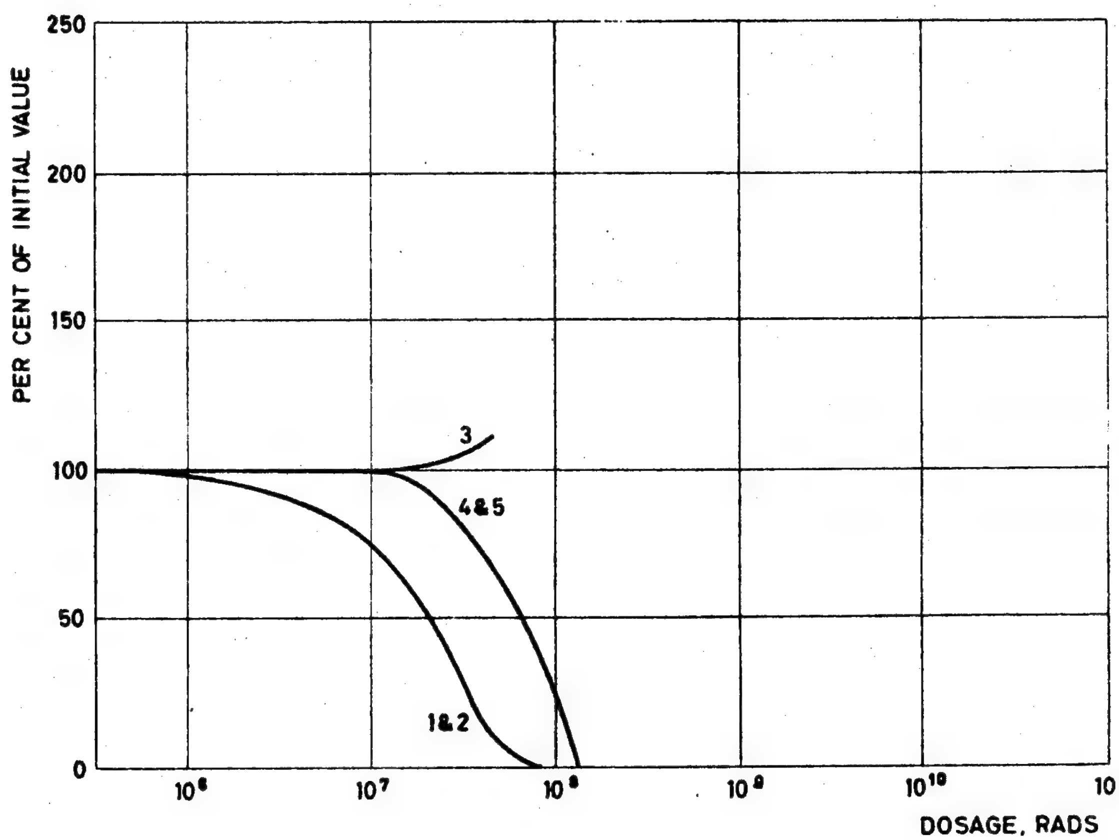
Effect of radiation on mechanical properties



CURVE N°	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	23.000 PSI
2	ELONGATION	—
3	ELASTIC MODULUS	—
4	SHEAR STRENGTH	—
5	IMPACT STRENGTH	—

Fig. 18 POLYIMIDE " H-FILM " (30)

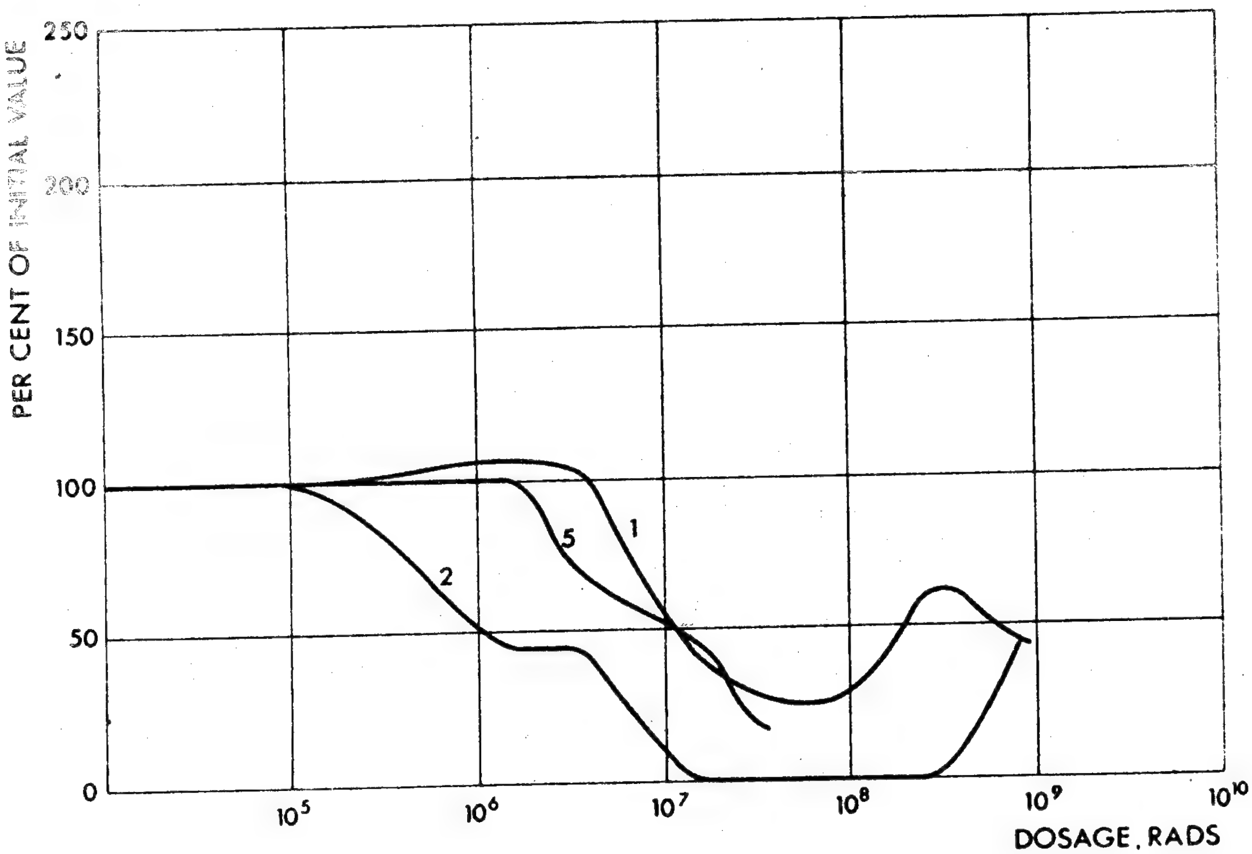
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	10,700 PSI
2	ELONGATION	4.5 %
3	ELASTIC MODULUS	4.8×10^5 PSI
4	SHEAR STRENGTH	6,700 PSI
5	IMPACT STRENGTH	0,37 FT-LB/IN. OF NOTCH

Fig. 19 Methyl methacrylate - "Perspex" (7,8,11,17,24,31,32,33)

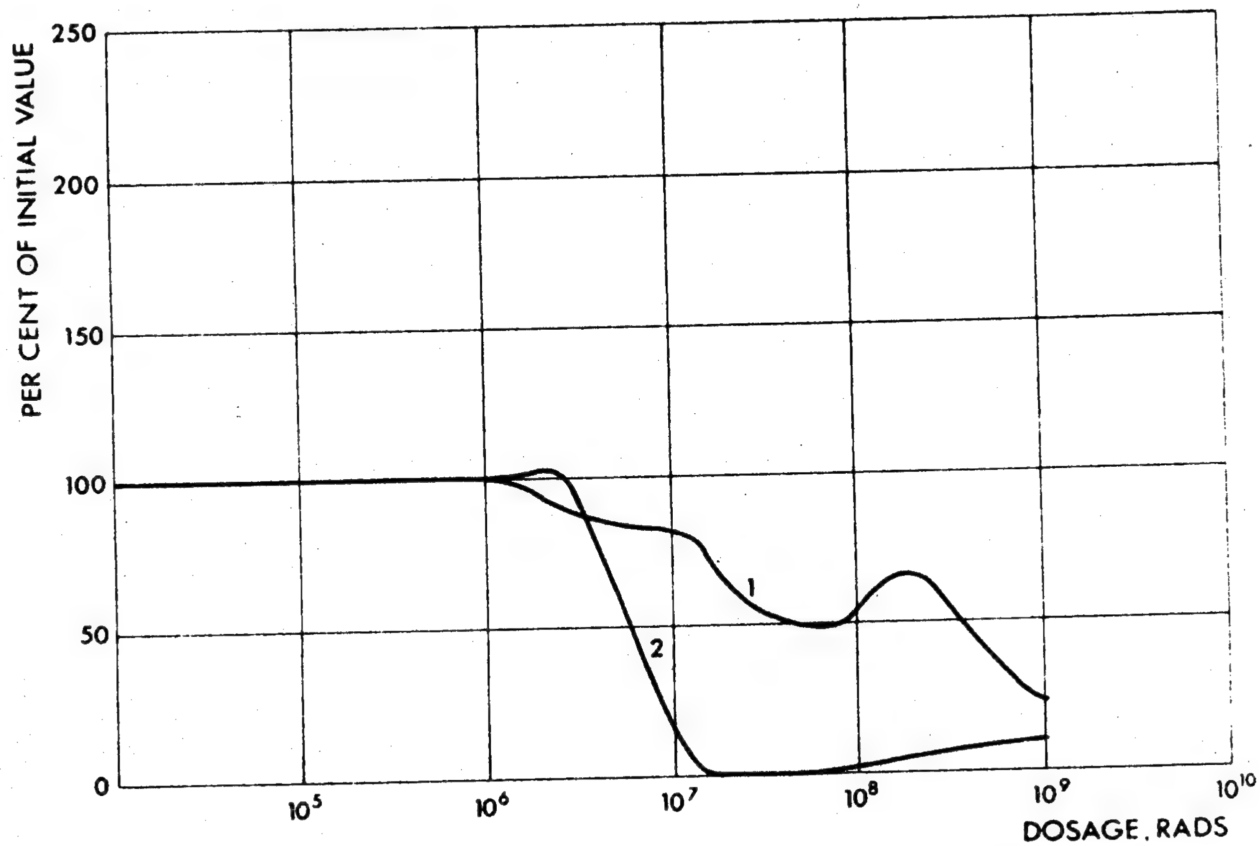
Effect of radiation on mechanical properties



CURVE N°	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	4.660 PSI
2	ELONGATION	70%
3	ELASTIC MODULUS	—
4	SHEAR STRENGTH	—
5	IMPACT STRENGTH	0,79 FT-LB/IN of notch

Fig. 20 POLYPROPYLENE "PRO-FAX" (34,35,36,37)

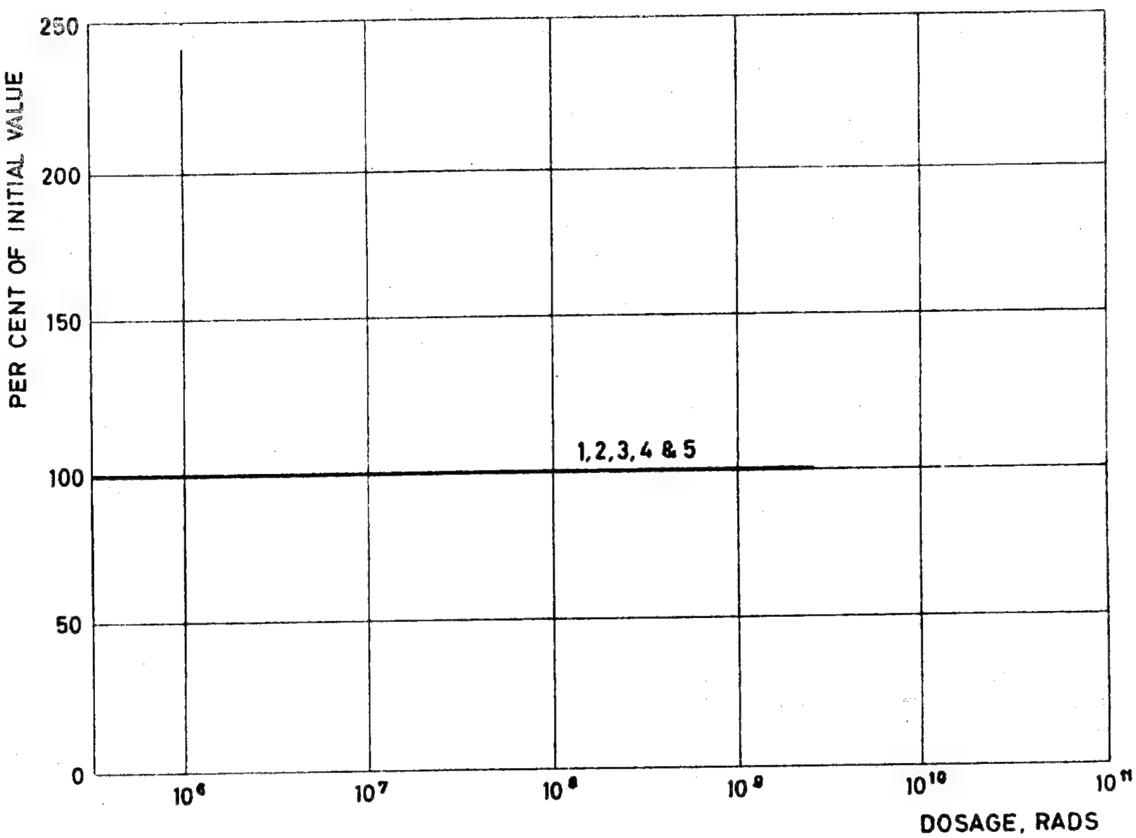
Effect of radiation on mechanical properties



CURVE Nº	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	4.380 PSI
2	ELONGATION	770%
3	ELASTIC MODULUS	–
4	SHEAR STRENGTH	–
5	IMPACT STRENGTH	–

Fig. 21 POLYPROPYLENE-ETHYLENE POLYALLOMER (6)

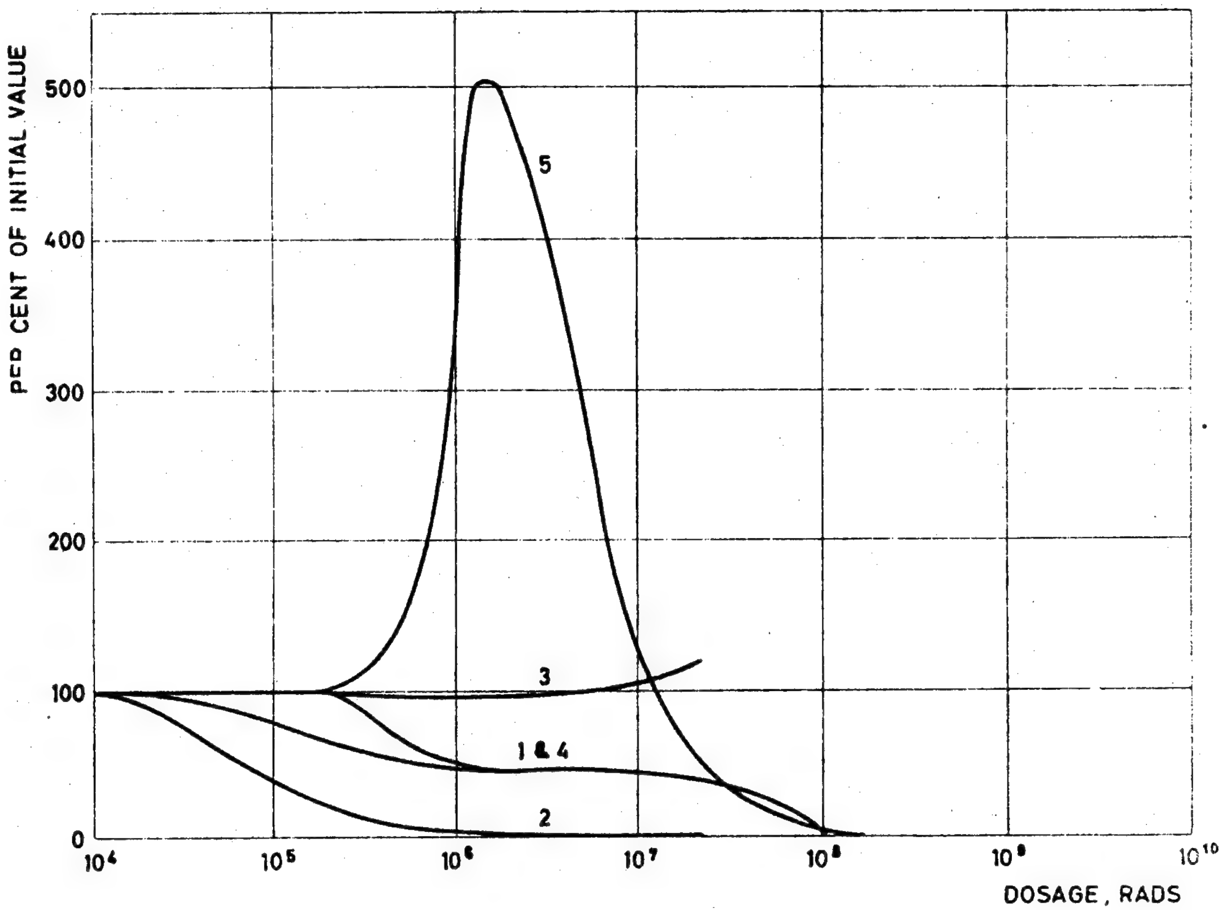
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	4,400 PSI
2	ELONGATION	1.0 %
3	ELASTIC MODULUS	4.8×10^5 PSI
4	SHEAR STRENGTH	5,500 PSI
5	IMPACT STRENGTH	0.20 FT-LB / IN. OF NOTCH

Fig. 22 Polystyrene - "Styron" (7,8,11,38,39)

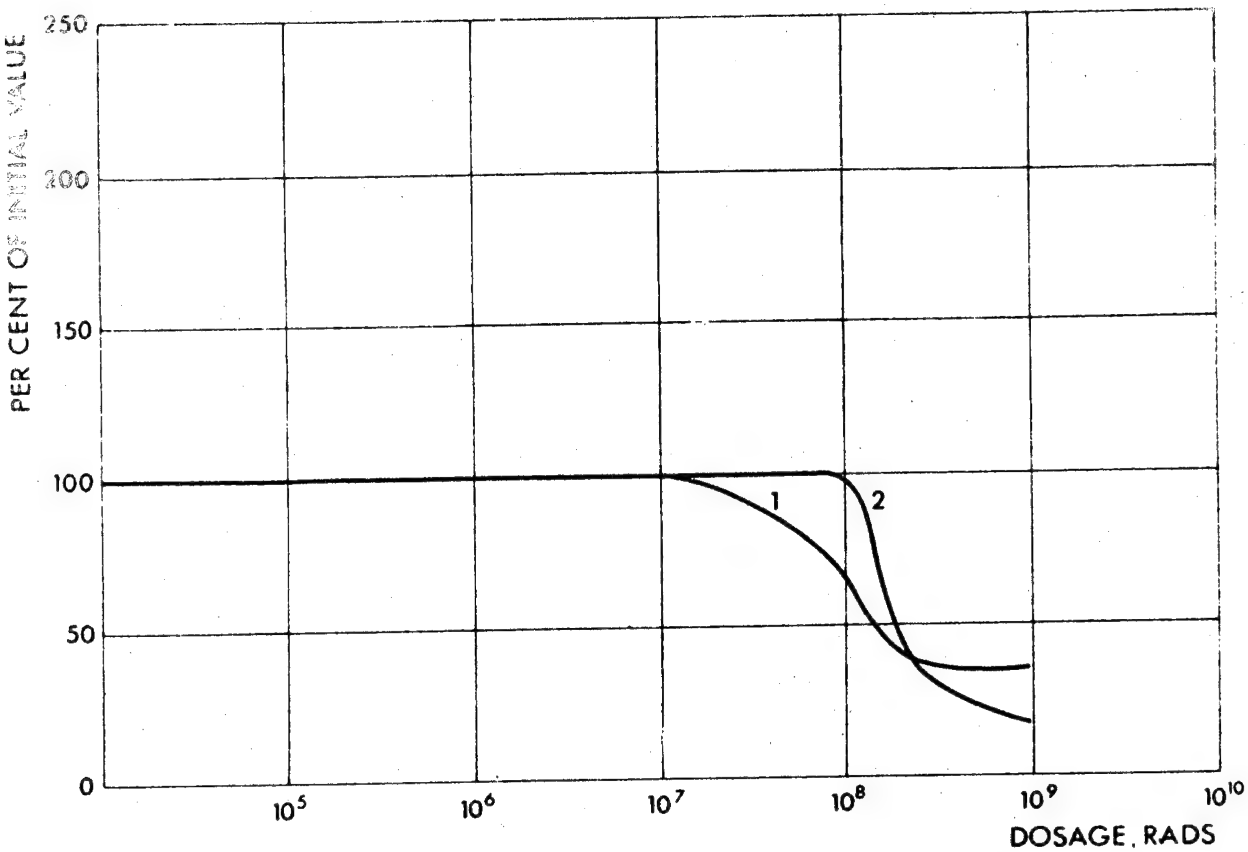
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	3,400 PSI
2	ELONGATION	250 %
3	ELASTIC MODULUS	1.0×10^5 PSI
4	SHEAR STRENGTH	2,830 PSI
5	IMPACT STRENGTH	3.3 FT-LB/IN. OF NOTCH

Fig. 23 Polytetrafluoroethylene(P.T.F.E.) "Teflon" (7, 8,11,20)

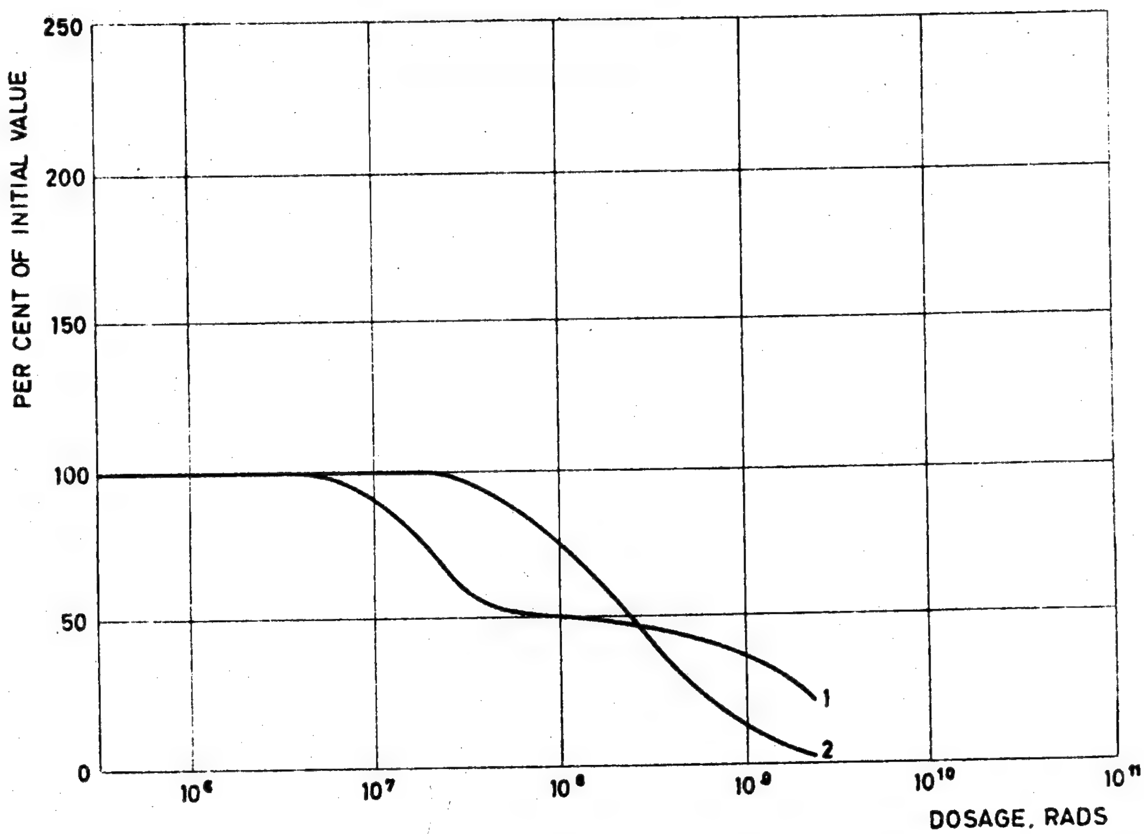
Effect of radiation on mechanical properties



CURVE N°	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	6.390 PSI
2	ELONGATION	500%
3	ELASTIC MODULUS	—
4	SHEAR STRENGTH	—
5	IMPACT STRENGTH	—

Fig. 24 POLYURETHANE "ESTANE VC" (1,12,40,41)

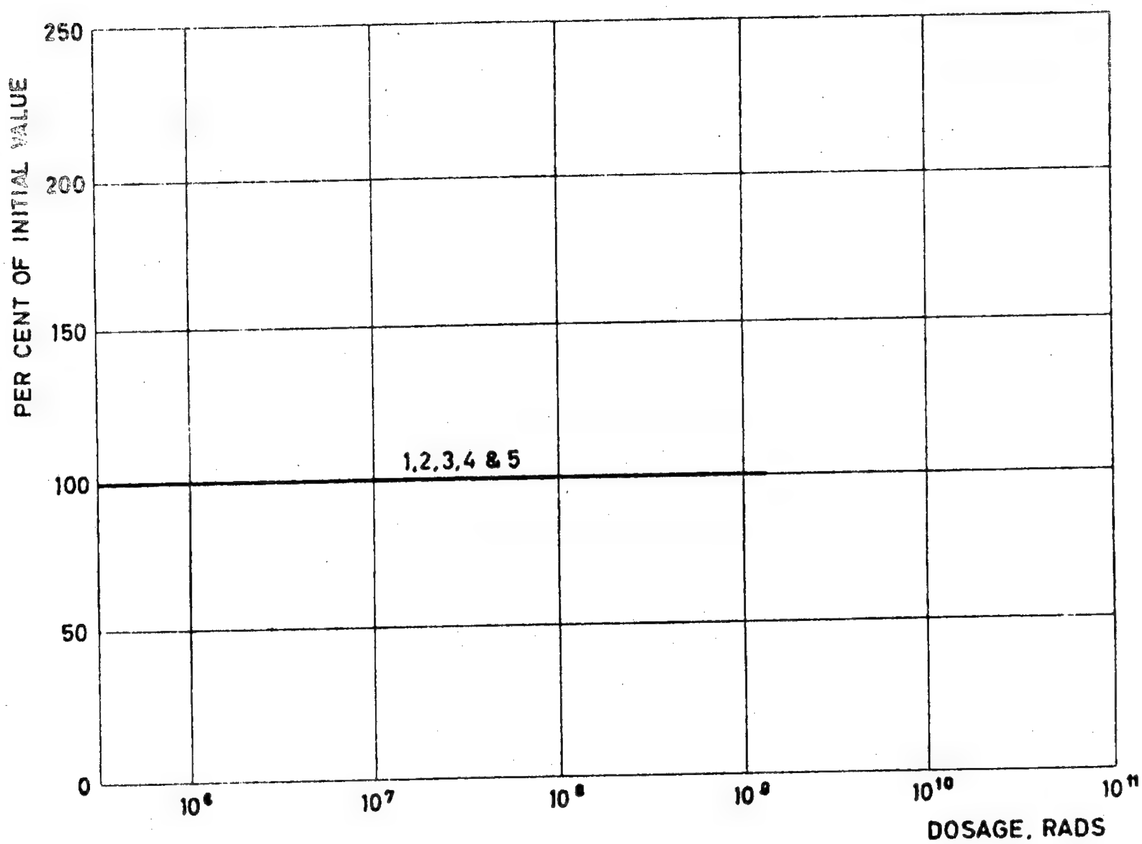
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	2200 PSI
2	ELONGATION	225 %
3	ELASTIC MODULUS	—
4	SHEAR STRENGTH	—
5	IMPACT STRENGTH	—

Fig. 25 Polyvinyl butyral - "Butacite Film" (7,8,11)

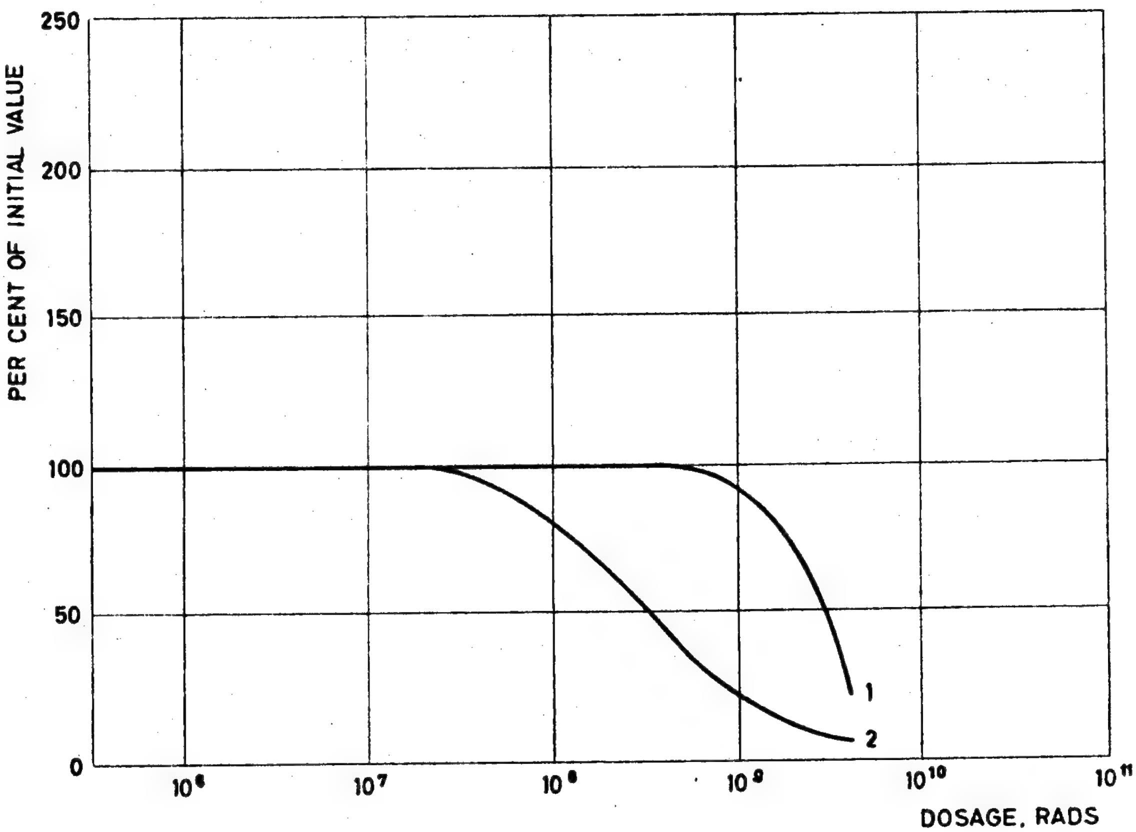
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	1,800 PSI
2	ELONGATION	0.32 %
3	ELASTIC MODULUS	5.8×10^5 PSI
4	SHEAR STRENGTH	3,500 PSI
5	IMPACT STRENGTH	0.19 FT-LB/IN. OF NOTCH

Fig. 26 Polyvinyl carbazole - "Polectron" (7, 8,11)

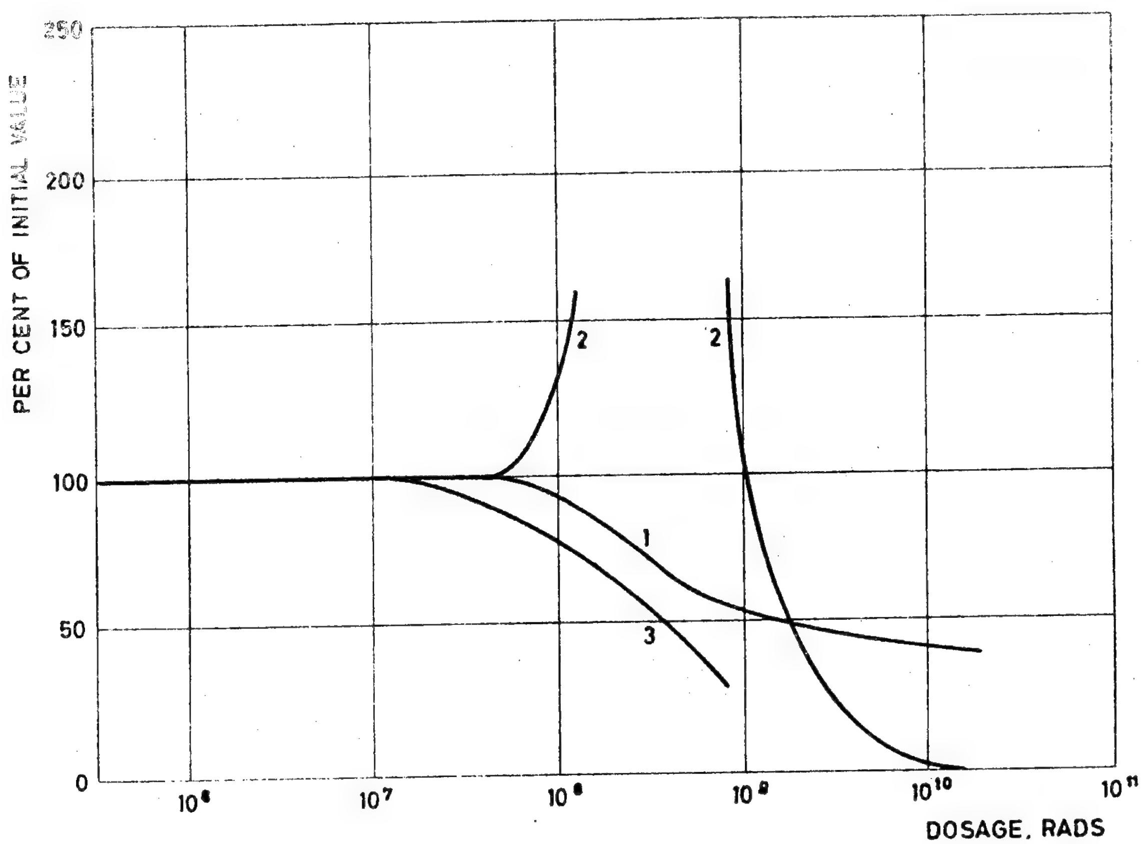
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	2,800 PSI
2	ELONGATION	310 %
3	ELASTIC MODULUS	—
4	SHEAR STRENGTH	—
5	IMPACT STRENGTH	—

Fig. 27 Polyvinyl chloride - "Geon" (7,8,11, 42)

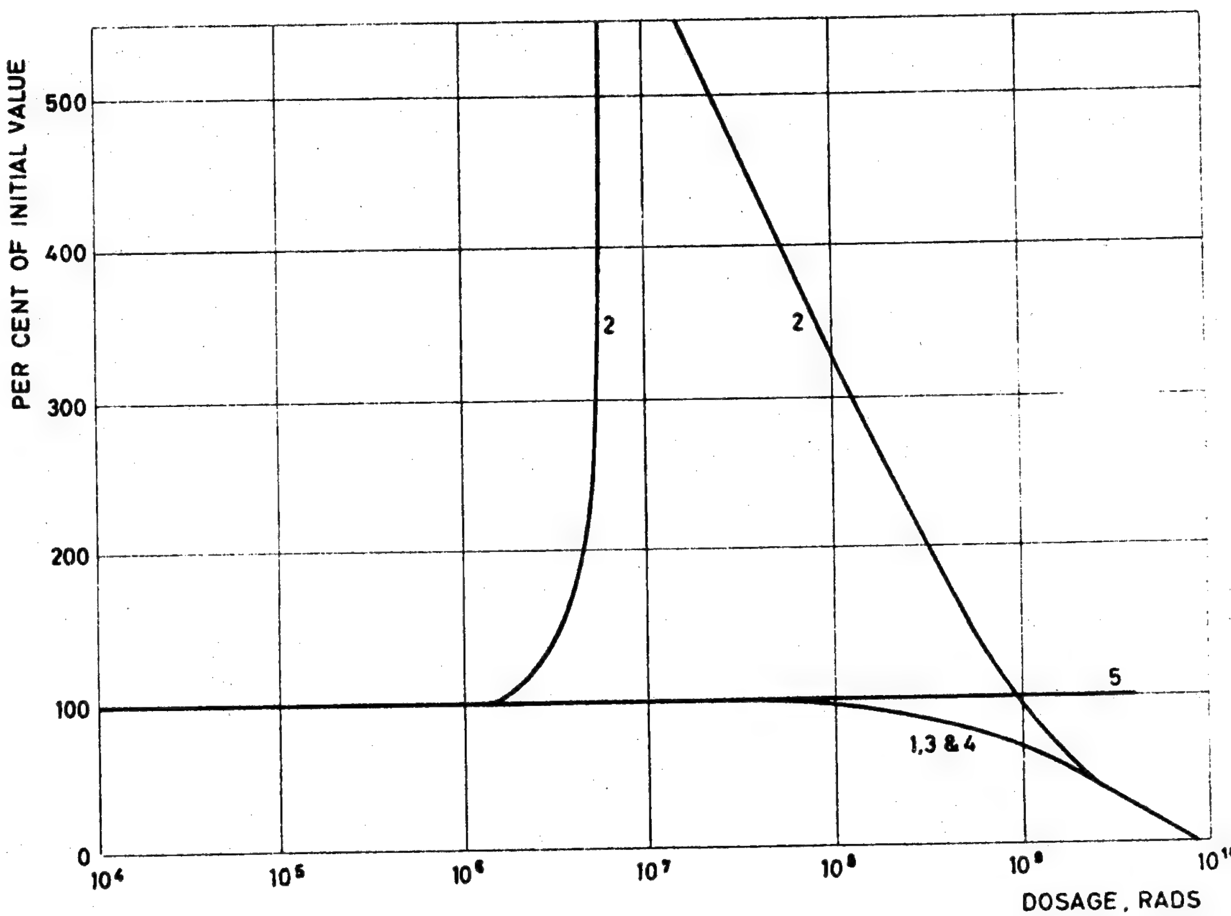
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	7400 PSI
2	ELONGATION	2 %
3	ELASTIC MODULUS	5×10^5 PSI
4	SHEAR STRENGTH	—
5	IMPACT STRENGTH	—

Fig. 28 Polyvinyl formal - "Formvar" (7,11)

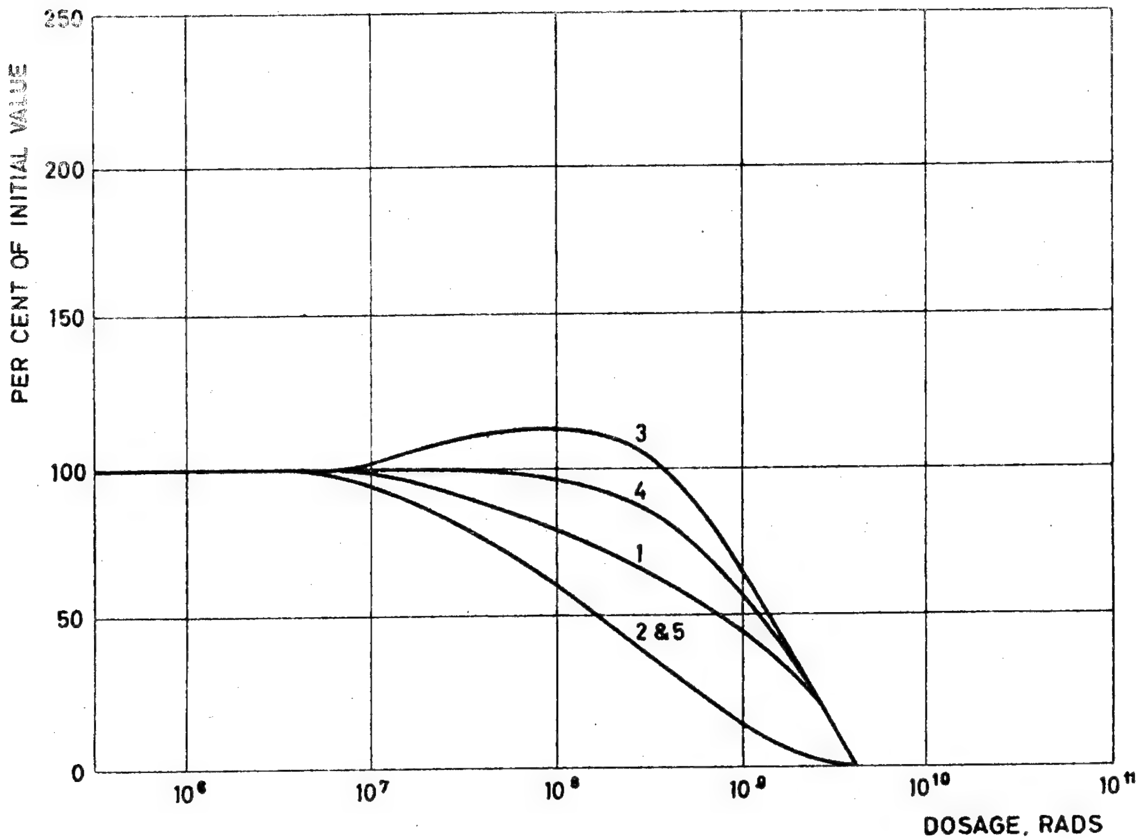
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	9,000 PSI
2	ELONGATION	3.1 %
3	ELASTIC MODULUS	4.8×10^5 PSI
4	SHEAR STRENGTH	6,800 PSI
5	IMPACT STRENGTH	0.5 FT-LB/IN. OF NOTCH

Fig. 29 Vinyl chloride acetate - "Vinylite" (7,8,11,43,44)

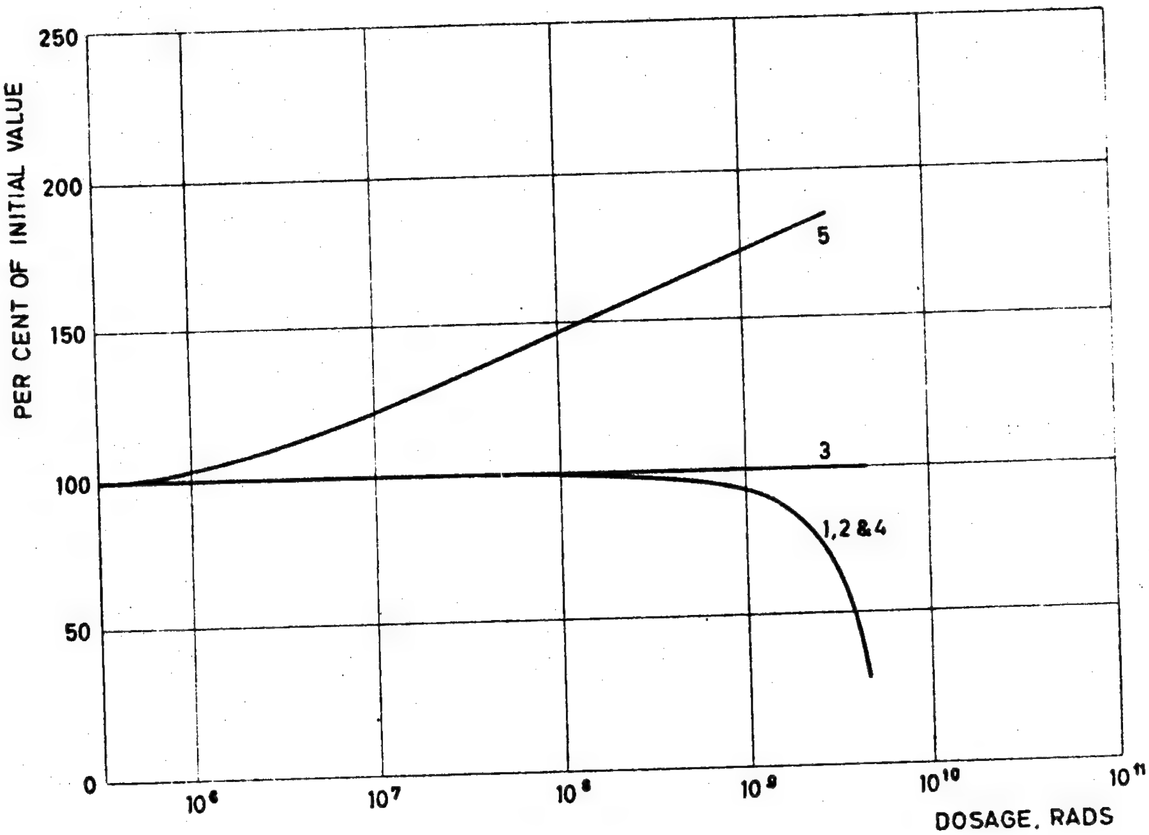
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	3,700 PSI
2	ELONGATION	200 %
3	ELASTIC MODULUS	0.65×10^5 PSI
4	SHEAR STRENGTH	2,900 PSI
5	IMPACT STRENGTH	1.6 FT-LB/IN. OF NOTCH

Fig. 30 Vinylidene chloride - "Saran" (7,8,11,43,45)

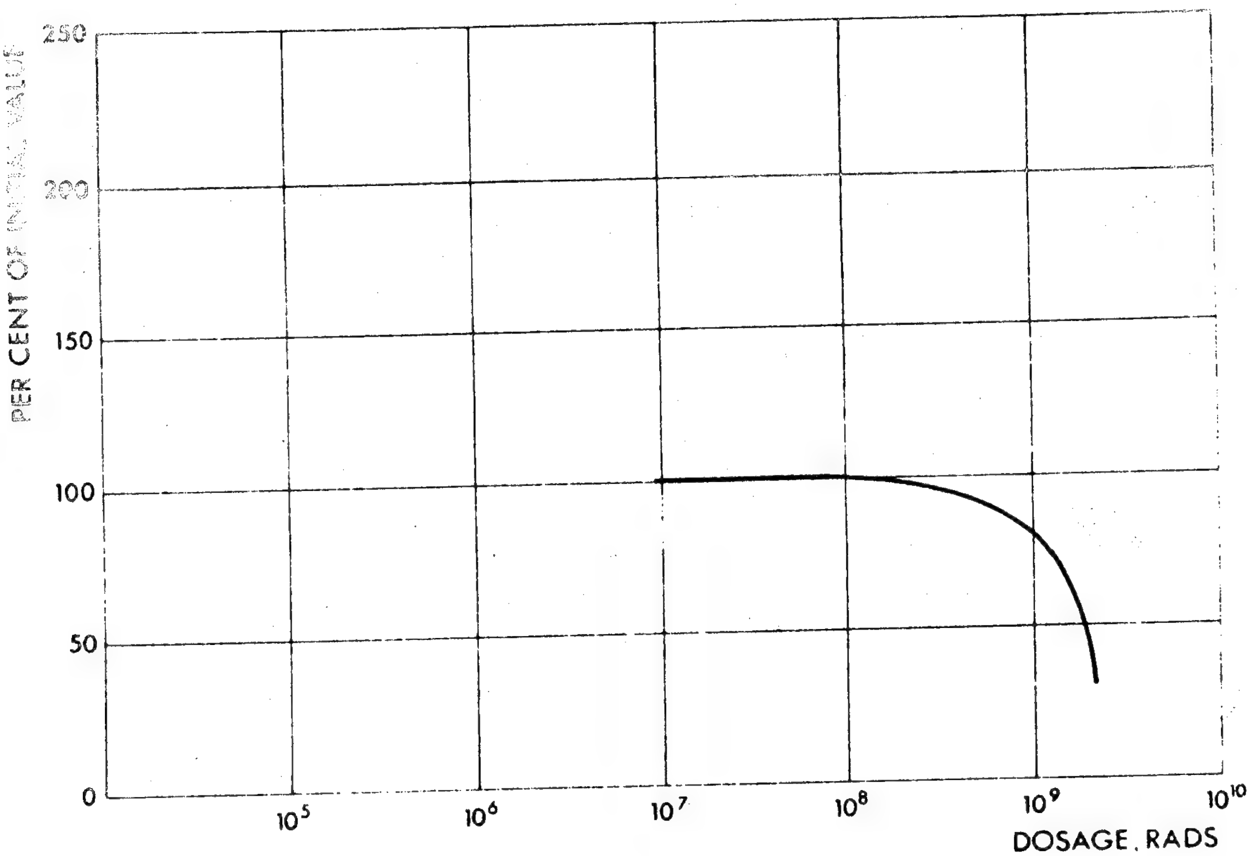
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	9,200 PSI
2	ELONGATION	1.8 %
3	ELASTIC MODULUS	6.0×10^5 PSI
4	SHEAR STRENGTH	9,700 PSI
5	IMPACT STRENGTH	0.20 FT-LB/IN. OF NOTCH

Fig. 31 Aniline formaldehyde - unfilled - "Cibanite" (7,8,11)

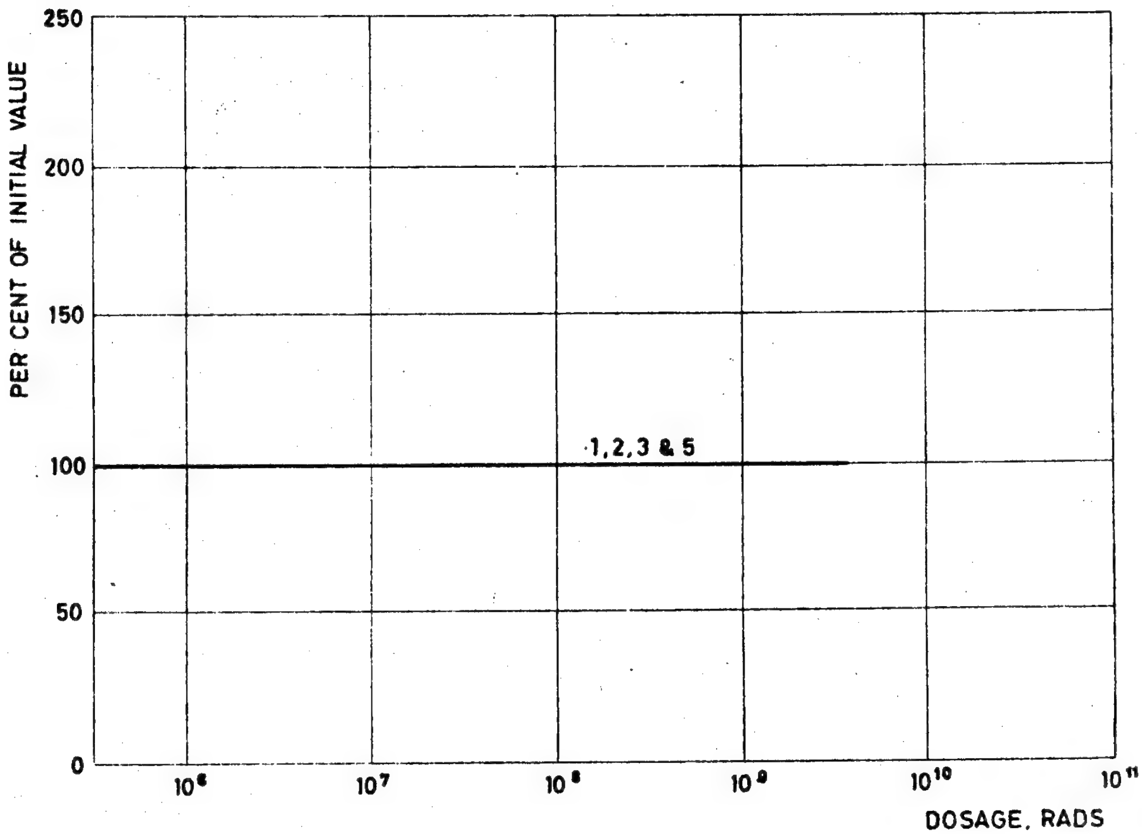
Effect of radiation on mechanical properties



CURVE N°	PROPERTY	INITIAL VALUE
1	FLEXURAL STRENGTH	238 PSI
2	—	
3	—	
4	—	
5	—	

Fig. 32 EPOXY – "ARALDITE" (46)

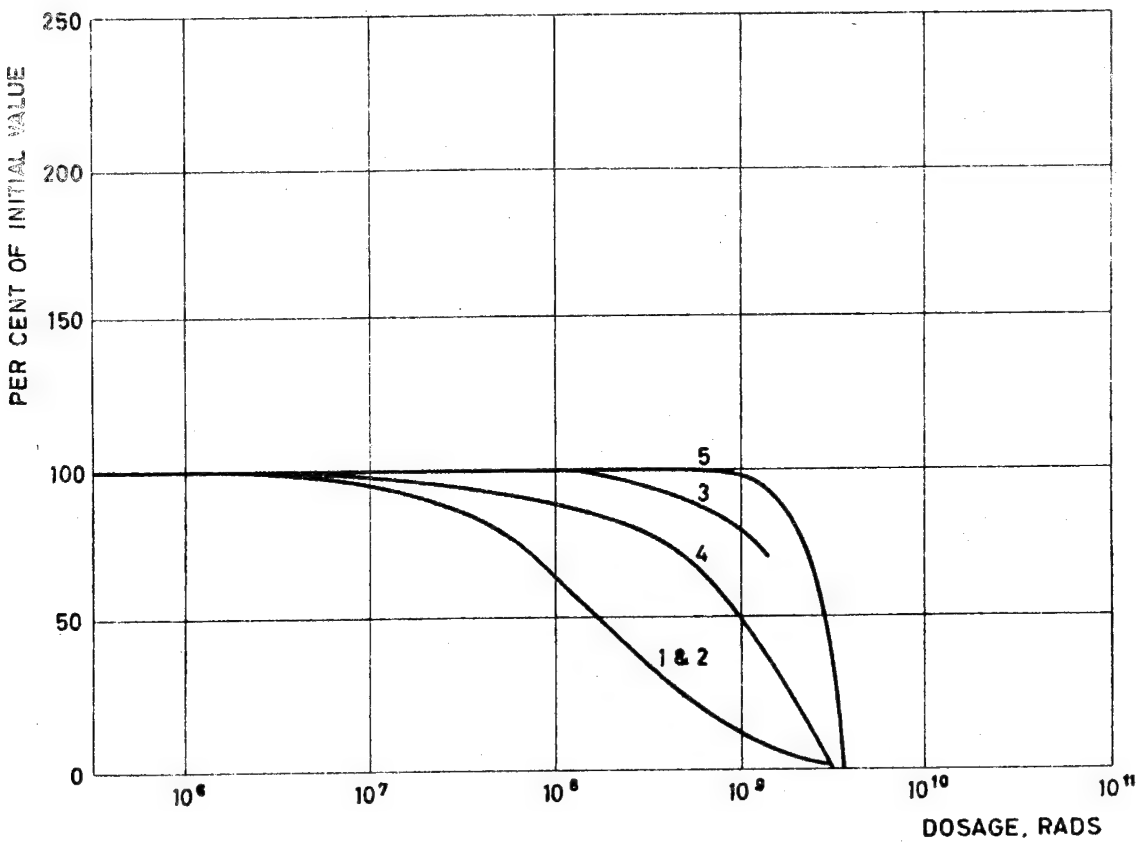
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	2,200 PSI
2	ELONGATION	0.39 %
3	ELASTIC MODULUS	8×10^5 PSI
4	SHEAR STRENGTH	—
5	IMPACT STRENGTH	0.31 FT-LB/IN. OF NOTCH

Fig. 33 Furan-asbestos and carbon black filler - "Duralon" (7,8,11,12)

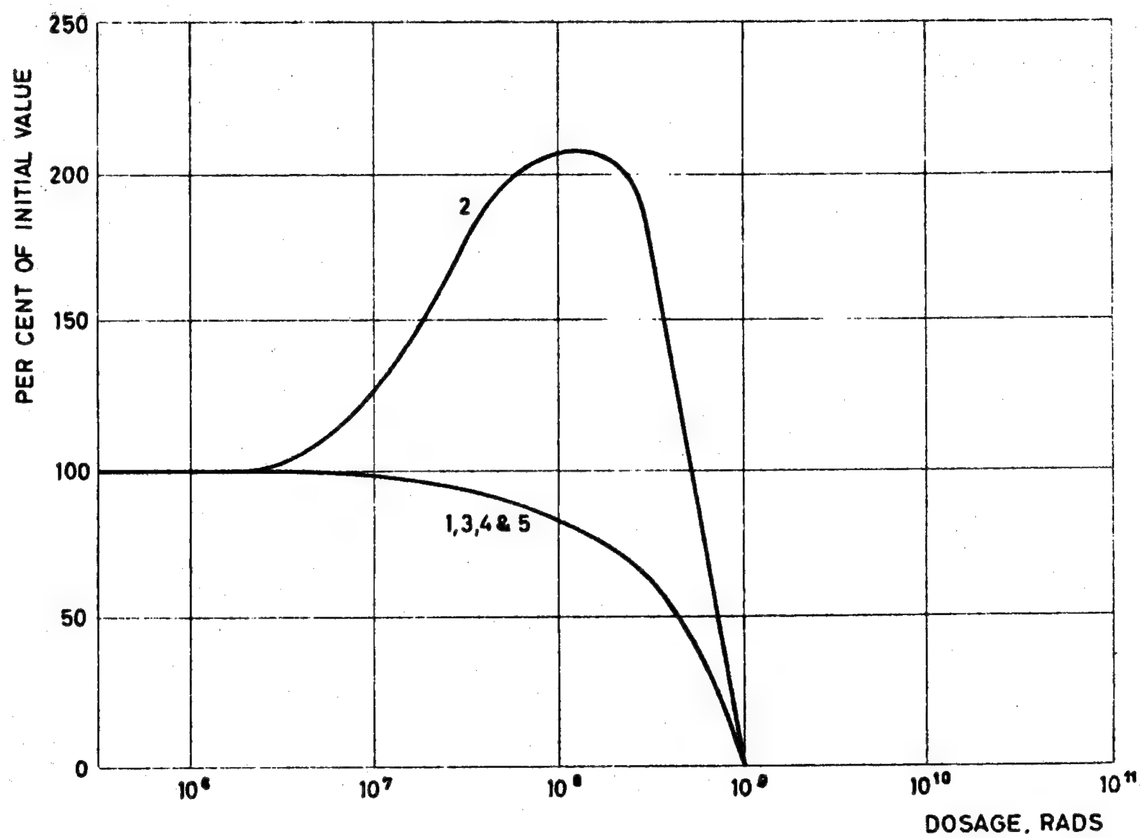
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	9,100 PSI
2	ELONGATION	0.65 %
3	ELASTIC MODULUS	14×10^5 PSI
4	SHEAR STRENGTH	11,000 PSI
5	IMPACT STRENGTH	0.29 FT-LB/IN. OF NOTCH

Fig. 34 Melamine formaldehyde-cellulose filler - "Melmac" (7,8,11,12)

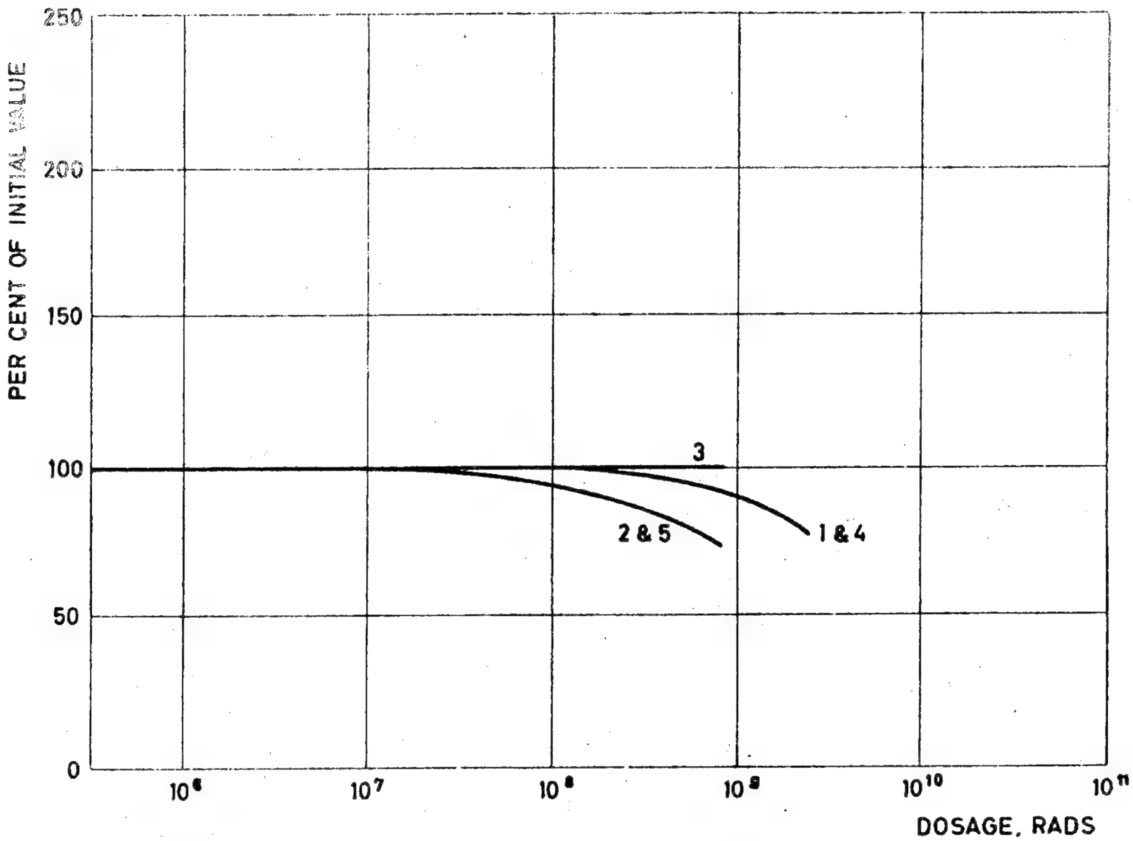
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	10,000 PSI
2	ELONGATION	2%
3	ELASTIC MODULUS	6×10^5 PSI
4	SHEAR STRENGTH	8,600 PSI
5	IMPACT STRENGTH	0.53 FT-LB/IN. OF NOTCH

Fig. 35 Phenol formaldehyde - "Catalin" (7,8,9,10,11,45)

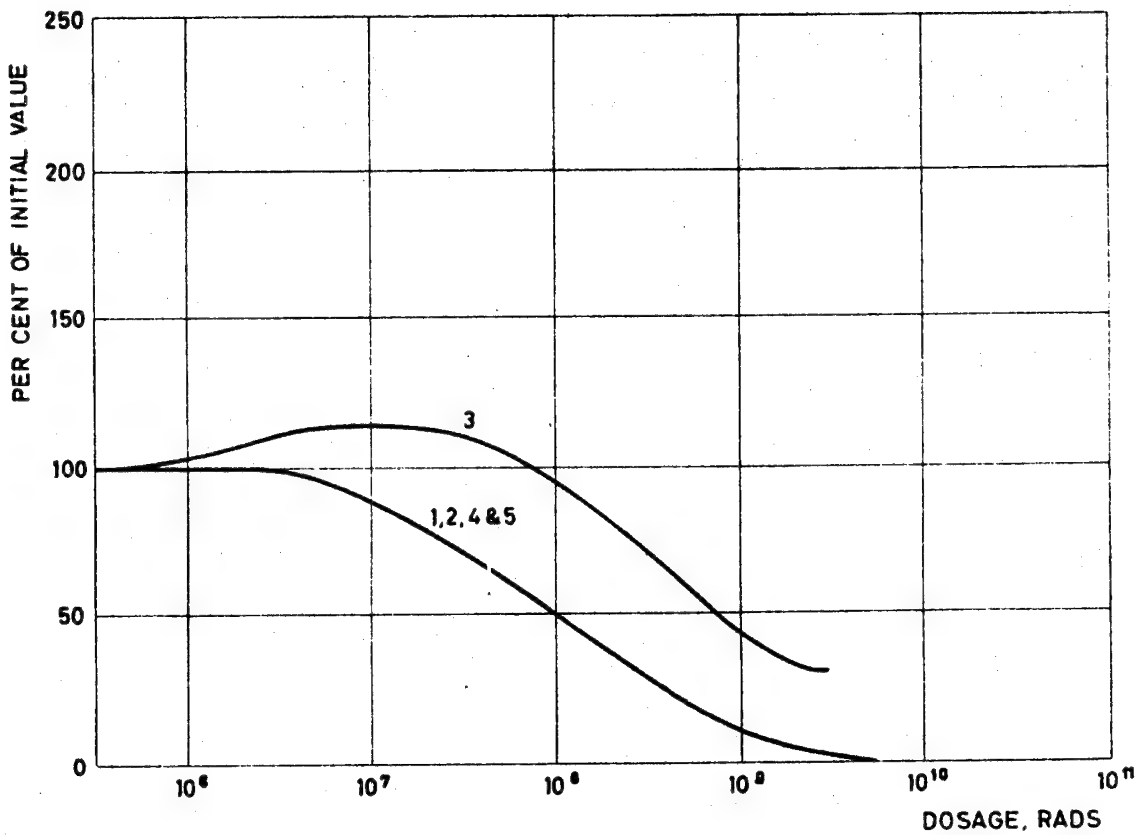
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	11,000 PSI
2	ELONGATION	1.3 %
3	ELASTIC MODULUS	18×10^5 PSI
4	SHEAR STRENGTH	15,000 PSI
5	IMPACT STRENGTH	5.2 FT-LB / IN. OF NOTCH

Fig. 36 Phenol formaldehyde - asbestos laminate filler - "Bakelite" (7, 8, 9, 11)

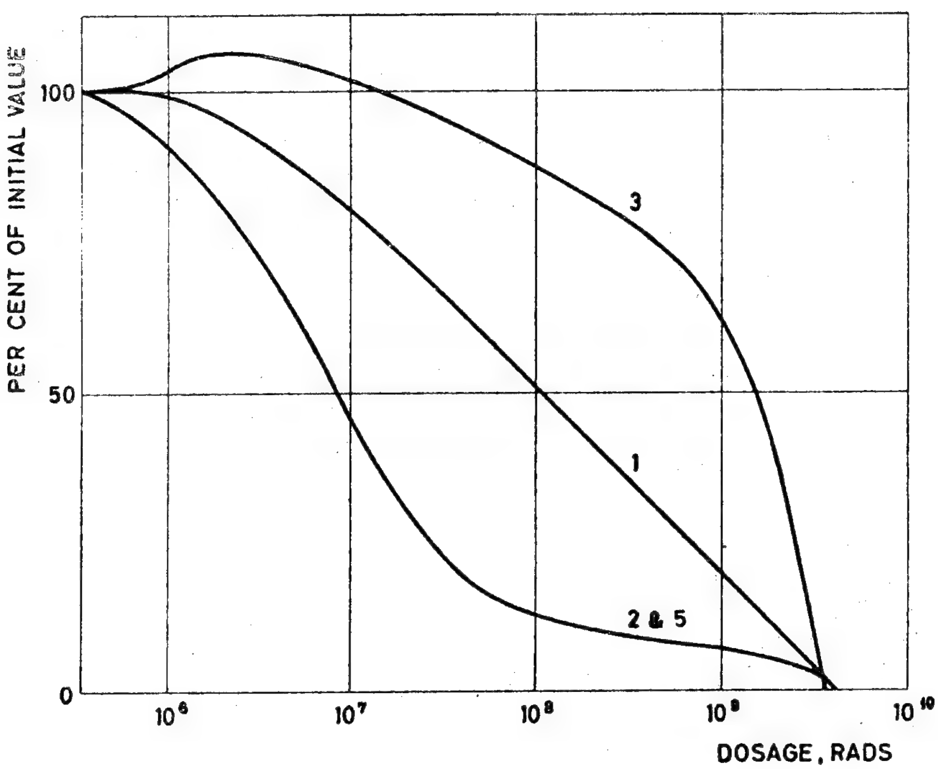
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	12,100 PSI
2	ELONGATION	1,8 %
3	ELASTIC MODULUS	16×10^5 PSI
4	SHEAR STRENGTH	14,400 PSI
5	IMPACT STRENGTH	0.58 FT-LB/IN. OF NOTCH

Fig. 37 Phenol formaldehyde - paper filler - "Bakelite" (7, 8, 9, 11)

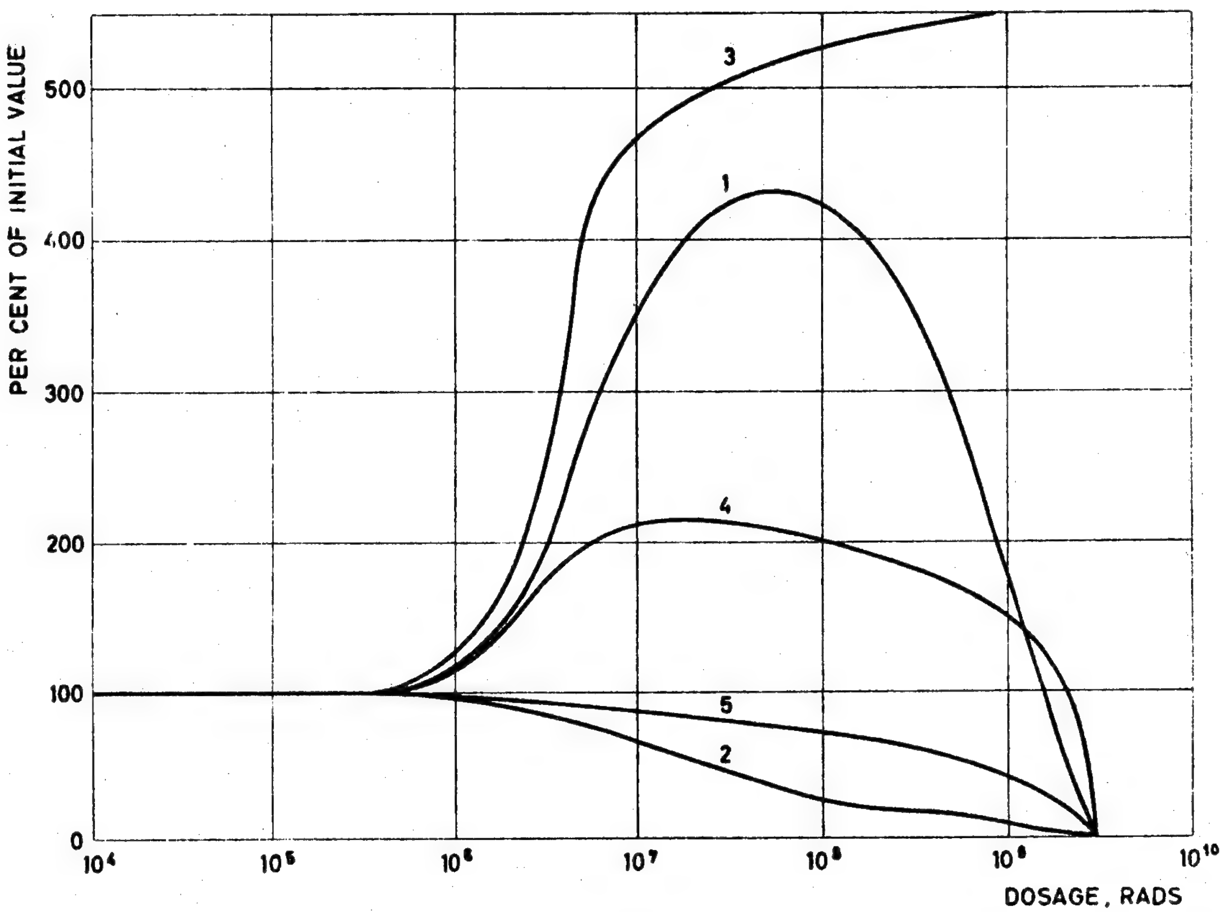
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	11,000 PSI
2	ELONGATION	4.0 %
3	ELASTIC MODULUS	11×10^6 PSI
4	SHEAR STRENGTH	—
5	IMPACT STRENGTH	2.75 FT-LB/IN. OF NOTCH

Fig. 38 Phenol formaldehyde-linen laminate filler-"Bakelite" (7,8)

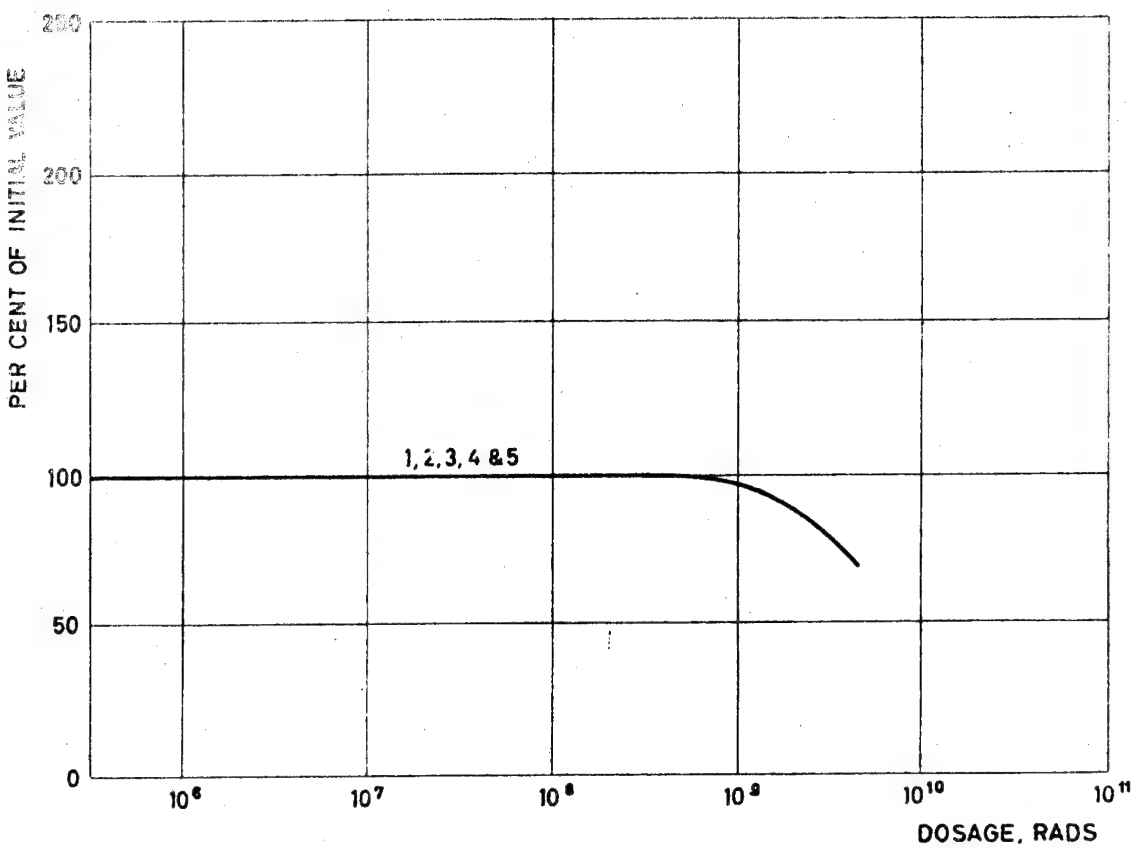
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	2,000 PSI
2	ELONGATION	20 %
3	ELASTIC MODULUS	0.58×10^5 PSI
4	SHEAR STRENGTH	3,100 PSI
5	IMPACT STRENGTH	0.73 FT-LB/IN OF NOTCH

Fig. 39 Polyester - "Selectron" (7,8,9,11,47,48,49)

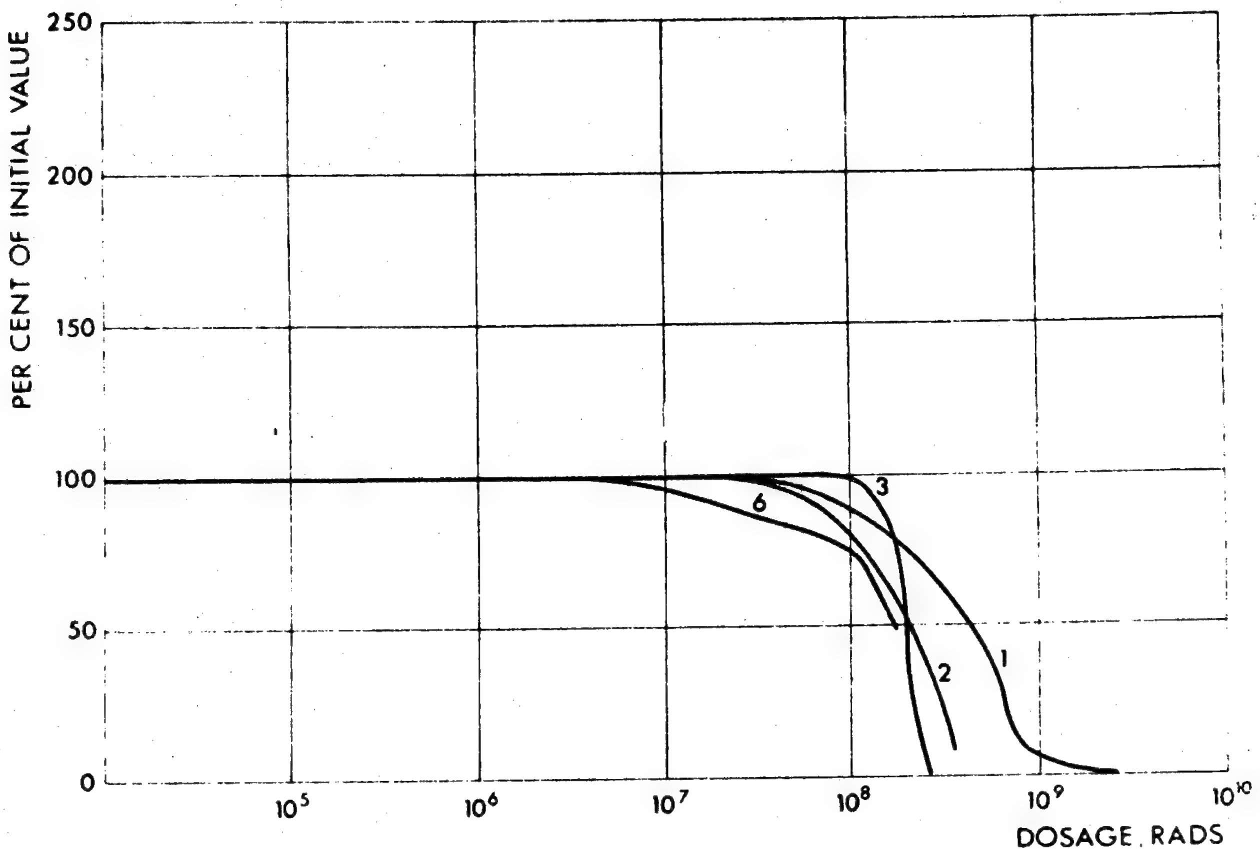
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	4,700 PSI
2	ELONGATION	0.17 %
3	ELASTIC MODULUS	32×10^5 PSI
4	SHEAR STRENGTH	7,000 PSI
5	IMPACT STRENGTH	0.36 FT-LB/IN. OF NOTCH

Fig. 40 Polyester - mineral filler - "Plaskon Alkyd" (7, 8, 9, 11)

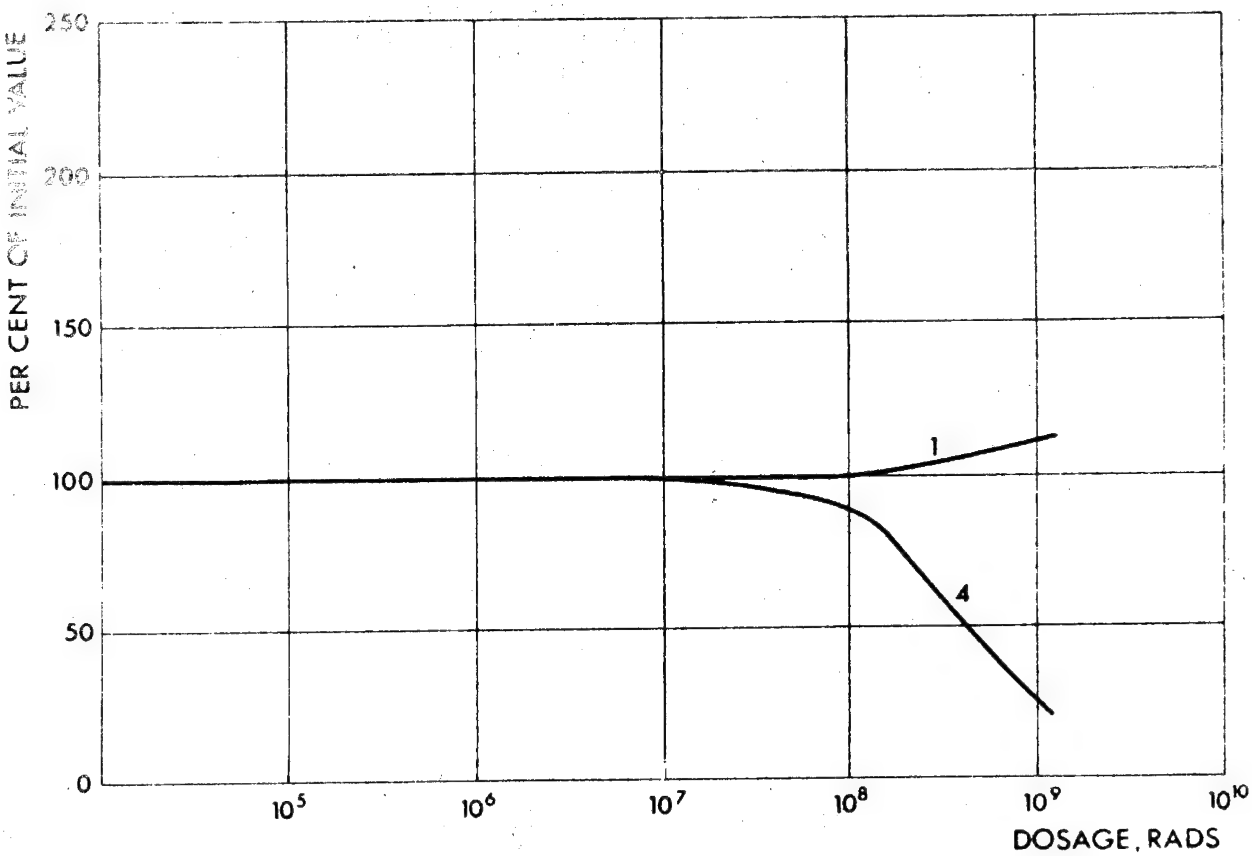
Effect of radiation on mechanical properties



CURVE N°	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	25.000 PSI
2	ELONGATION	50%
3	ELASTIC MODULUS	2,95 10^5 PSI
4	SHEAR STRENGTH	–
5	IMPACT STRENGTH	–
6	BURSTING PRESSURE	105 PSI

Fig.41 POLYETHYLENE TEREPHTHALATE "MYLAR FILM" (30,50,51,52)

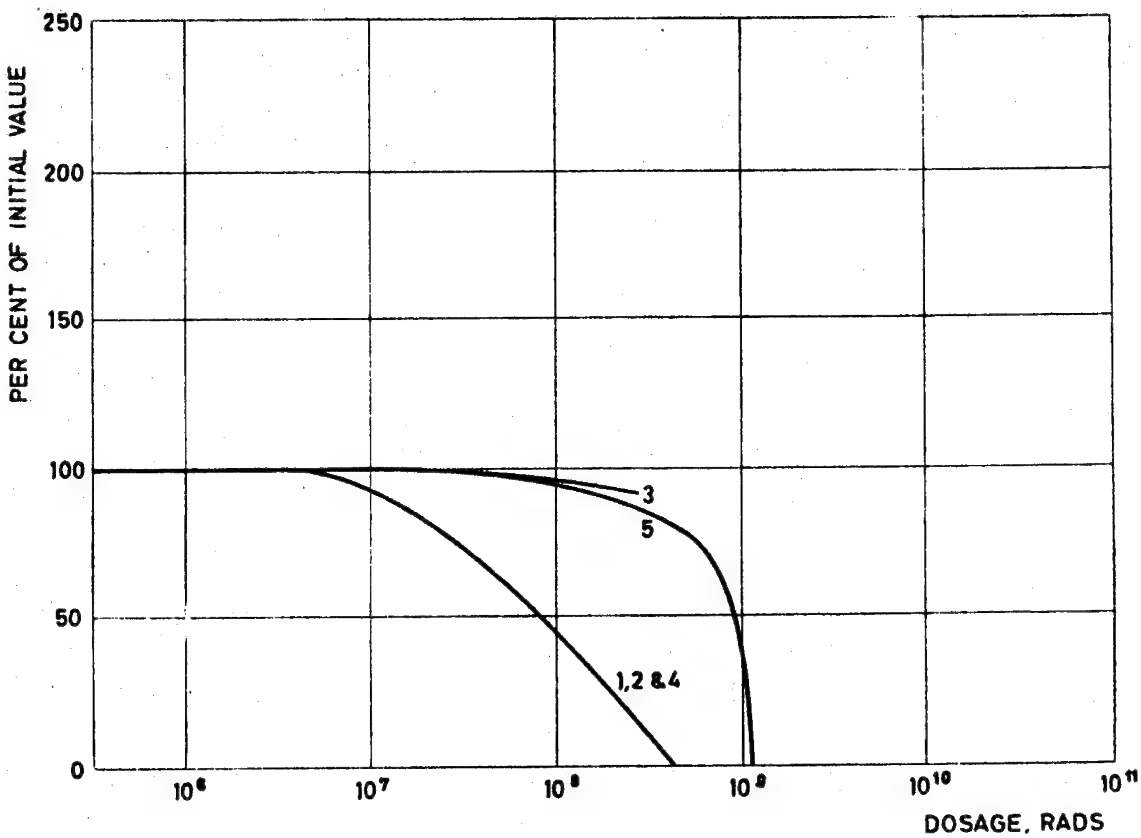
Effect of radiation on mechanical properties



CURVE N°	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	16.000 PSI
2	ELONGATION	—
3	ELASTIC MODULUS	—
4	SHEAR STRENGTH	13.500 PSI
5	IMPACT STRENGTH	—

Fig. 42 SILICONE, GLASS FILLED (7,8,9,11,53,54,55)

Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	7,800 PSI
2	ELONGATION	0,5 %
3	ELASTIC MODULUS	14×10^5 PSI
4	SHEAR STRENGTH	10,000 PSI
5	IMPACT STRENGTH	0.30 FT-LB/IN. OF NOTCH

Fig. 43 Urea formaldehyde - "Beetle" (7, 8, 12)

Table 9 (7) (8) (11) (12)

Material (Trade names)	Absorbed dose, Rads x10^{+8}	Rockwell hardness, R scale	Water absorption %	Specific gravity
Casein (Ameroid)	0	125	9,0	1,34
	0,045	125	9,5	1,34
	0,45	125	13,0	1,34
	4,5	-	-	-
	45	-	-	-
Cellulose Acetate (Plastacele)	0	102	3	1,31
	0,035	102	3	1,31
	0,35	104	4	1,31
	3,5	-	-	-
	35	-	-	-
Cellulose Propionate (Tenite Propionate)	0	83	1	1,19
	0,037	80	1	1,19
	0,37	-	1	1,19
	3,7	-	-	-
	37	-	-	-
Cellulose Acetate Butyrate (Tenite Butyrate)	0	88	1,1	1,19
	0,037	86	1,1	1,19
	0,37	80	1,2	1,19
	3,7	-	-	-
	37	-	-	-
Cellulose Nitrate (Pyralin)	0	111	1,2	1,41
	0,03	112	1,2	1,41
	0,3	116	1,2	1,41
	3	-	-	-
	30	-	-	-
Ethyl Cellulose (Ethocel)	0	113	1,2	1,13
	0,042	113	1,2	1,13
	0,42	112	1,2	1,13
	4,2	-	-	-
	42	-	-	-
Polyethylene (Polythene)	0	-20	0,02	0,91
	0,06	-20	0,02	0,91
	0,6	+10	0,02	0,91
	6	60	0,02	0,92
	60	120	0,03	0,96

Material (Trade names)	Absorbed dose, Rads x 10^{+8}	Rockwell hardness, R scale	Water absorption %	Specific gravity
Polychlorotrifluoro-ethylene (Fluorothene)	0	110	0,01	2,12
	0,06	110	0,01	2,12
	0,6	106	0,01	2,12
	6	-	-	-
	60	-	-	-
Polytetrafluoro-ethylene (Teflon)	0	35	0,04	2,17
	0,02	20	0,04	2,18
	0,2	35	0,04	2,20
	2	-	0,04	2,23
	20	-	-	-
Polyvinylchloride acetate (Vinylite)	0	120	0,05	1,36
	0,15	115	0,1	1,36
	1,5	112	0,4	1,36
	15	92	0,8	1,34
	150	-	-	-
Polyvinyl formal (Formvar)	0	-	-	1,21
	0,04	-	-	1,21
	0,4	-	-	1,20
	4	-	-	1,17
	40	-	-	1,14
Polymethylmetha-crylate (Perspex)	0	122	0,4	1,19
	0,04	122	0,4	1,19
	0,4	122	0,4	1,19
	4	-	-	-
	40	-	-	-
Polystyrene unpigmented (Amphenol)	0	122	0,05	1,05
	0,04	122	0,05	1,05
	0,4	122	0,05	1,05
	4	122	0,07	1,05
	40	122	0,10	1,06
Allyldiglycol-carbonate (CR 39)	0	118	0,4	1,31
	0,037	118	0,4	1,31
	0,37	115	0,5	1,31
	3,7	90	1,2	1,29
	37	-	2,8	1,23
Polyester (Plaskon Alkyd)	0	122	0,2	2,22
	0,035	122	0,2	2,22
	0,35	122	0,2	2,22
	3,5	122	0,3	2,21
	35	108	0,7	2,18

Material (Trade names)	Absorbed dose, Rads x10^{+8}	Rockwell hardness, R scale	Water absorption %	Specific gravity
Polyester (Selectron)	0	50	0,6	1,25
	0,035	110	0,6	1,25
	0,35	120	0,6	1,25
	3,5	110	0,6	1,26
	35	-	0,8	1,21
Polyamide (Nylon)	0	105	1,5	1,142
	0,055	105	1,5	1,142
	0,55	108	1,5	1,142
	5,5	118	1,5	1,146
	55	123	13	1,156
Polyformaldehyde (Delrin)	0	75 D*	-	-
	0,02	81 D*	-	-
	0,05	84 D*	-	-
Polypropylene (Pro-Fax)	0	75 D*	-	-
	0,55	75 D*	-	-
	1	74 D*	-	-
	5	67 D*	-	-
	10	54 D*	-	-
Polyurethane (Estane VC)	0	87 D*	-	-
	1	88 D*	-	-
	5	90 D*	-	-
	10	92 D*	-	-

* Shore D hardness used

Table 10

Material (Trade names)	Absorbed. dose, Rads x 10^{+8}	Rockwell hardness, R scale	Water absorption %	Specific gravity
Aniline formaldehyde, no filler (Cibanite)	0	128	0,1	1,21
	0,045	128	0,1	1,21
	0,45	128	0,1	1,21
	4,5	127	0,1	1,21
	45	126	0,1	1,21
Furan, asbestos filler (Duralon)	0	117	0,8	1,85
	0,035	117	0,8	1,85
	0,35	117	0,7	1,85
	3,5	117	0,7	1,85
	35	118	1	1,85
Malamine formaldehyde, cellulose filler (Melmac)	0	128	1	1,46
	0,075	128	1	1,46
	0,75	128	1	1,46
	7,5	126	2	1,46
	75	106	11	1,20
Phenol formaldehyde, unfilled (Catalin)	0	123	0,3	1,3
	0,035	121	0,4	1,3
	0,35	118	0,5	1,3
	3,5	113	0,8	1,3
	35	-	-	powder
Phenol formaldehyde, Linen fabric laminate (Bakelite)	0	122	1	1,34
	0,035	122	1	1,34
	0,35	122	1	1,34
	3,5	122	2	1,34
	35	-	30	0,8
Phenol formaldehyde, Paper laminate (Bakelite)	0	122	1	1,37
	0,035	122	1	1,37
	0,35	122	1	1,37
	3,5	118	3	1,36
	35	106	80	0,8
Phenol formaldehyde, asbestos filler (Haveg)	0	110	4,2	1,66
	0,035	110	4,2	1,66
	0,35	110	4,2	1,66
	3,5	110	4,2	1,66
	35	110	4,2	1,66

Material (Trade names)	Absorbed dose, Rads x 10^{+3}	Rockwell hardness, R scale	Water absorption %	Specific gravity
Phenol formaldehyde, Graphite filler (Karbate)	0	84	4,5	1,70
	0,035	84	4,5	1,70
	0,35	85	4,5	1,69
	3,5	88	4,5	1,68
	35	100	4,5	1,68
Urea-formaldehyde, Cellulose filler (Beetle)	0	128	1,0	1,50
	0,06	128	1,0	1,50
	0,6	127	1,5	1,50
	6	120	20	1,47
	60	-	-	-

TABLE 11 (7) (.) (11) (4.) (55) (56) (57) (5)

Effect of nuclear radiation on volume resistivity, dielectric strength and Arc resistance of plastics.

A. THERMOPLASTIC

Material (Trade Names)	Specimen Thickness (inches)	Radiation Type and Energy in MeV	Dose Rate* 10^7 xrad/hr	Dosage 10^8 x rad	Volume Resistivity (ohm-cm)	Dielectric Strength Volts/mil	Arc Resistance seconds	Manner of failure
.llyl diglycol .arbonate polymer (CR-39)	0.30 0,125	Pile Pile	- -	0 15 0 5 3 15	- ~10^{14} 1.10^{13} 2.10^{12} -	50 600 - - - -	- - 120 - - 120	- - Melted - - Melted
Casein (Ameroid)	0.120	Pile	-	0 1 2	1.10^{11} 1.10^{11} -	600 - 300	70 60 -	Carbonized Carbonized -
Cellulose Acetate (Plastacele)	0.150	Pile	-	0 0,35 0,7 1,7 1,.	5.10^{12} 3.10^{12} 2.10^{11} 2.10^{11} -	- - - - -	190 - - - 190	Melted - - - Melted
Cellulose Acetate Butyrate (Tenite butyrate)	0,020 0,195	Pile Pile	- -	0 2 0 0,25 1	- - ~10^{14} 5.10^{13} 2.10^{12}	1.000 700 - - -	- - 140 115 55	- - Melted Melted Melted
Cellulose Nitrate (Pyralin)	0,025 0,122	Pile Pile	- -	0 1,5 0 0,9	- - 2.10^{11} 1.10^{11}	900 700 - -	- - 22 13	- - Melted Melted

* The irradiation in the pile took place at an approximate equivalent rate of 10^5 to 10^7 rads/hr.

56/3020/5
cms

TABLE 11 (Continued) (2)

Cellulose Propionate (Tenite propionate)	0,020 0,160	Pile Pile	- -	0 0,35 0 0,06 0,75 1,25	- $\to 10^{14}$ $\to 10^{14}$ -	1.000 1.000 - - - -	- - 125 120 - 110	- - Melted Melted - Melted
Ethyl Cellulose (Ethocel)	0,021 0,150	Pile Pile	- -	0 1 0 0,2 1,3	- - 1.10^{14} - 1.10^{14}	1.250 1.250 - - -	- - 120 100 0	- - Melted Melted Melted
Polyamid (Nylon)	0,032 0,140	Pile Pile	- -	0 2? 0 1,5 9,5 40	- - 1.10^{13} - - 4.10^{13}	660 660 - - - -	- - 120 100 50 70	- - Carbonized Carbonized Carbonized Carbonized
Polychlorotri-fluoroethylene (Fluorothene)	0,030 0,125	Pile Pile	- -	0 3 0 2	- - $\to 10^{14}$ $\to 10^{14}$	900 900 - -	- - 200 200	- - Melted Melted
Polyethylene (Polythene)	0,030 0,065 0,11 0,116	Pile Pile 2,0 (e^-) 2,5(X)	- - 5,3 1,2 0,54	0 90 0 55 30 0 0,7 0 0,3 0 0,4	- $\to 10^{14}$ $\to 10^{14}$ $\to 10^{15}$ $\to 10^{15}$ $\to 10^{15}$ $\to 10^{15}$ $\to 10^{15}$ $\to 10^{15}$ $\to 10^{15}$	600 500 - - - - - - - - -	- - 130 - 130 - - - - - -	- - Melted - Melted - - - - - -
Polyethylene terephthalate (Mylar)	0,002	Pile	-	0 2,1 3,6	1.10^{15} 1.10^{15} 1.10^{12}	- - -	- - -	- - -

-/5020/5
cms

TABLE 11 (Continued) (3)

Polyester, Mineral filled (Plaskon Alkyd)	0,120	Pile	-	0 25 45	$\rightarrow 10^{14}$ $\rightarrow 10^{14}$ 3.10^{13}	250 250 245	180 - 180	Carbonized - Carbonized
Polyester (Selectron)	0,021 0,250	Pile Pile	- -	0 12 0 8 18	- - 1.10^{11} 6.10^{12} $\rightarrow .10^{14}$	800 300 - - -	- - 63 - 69	- - Melted - Melted
Polymethyl methacrylate (Perspex)	0,021 0,060 0,118	Pile Pile 2,5(X)	- - 1,06 0,54	0 0,7 0 0,5 1 0 0,2 0 0,4	- - $\rightarrow 10^{14}$ - $\rightarrow 10^{14}$ $\rightarrow 10^{15}$ $\rightarrow 10^{15}$ $\rightarrow 10^{15}$ $\rightarrow 10^{15}$	1.000 1.000 - - - - - - -	- - 120 80 50 - - - -	- - Melted Melted Melted - - - -
Polystyrene, no pigment (Amphenol)	0,019 0,090	Pile Pile	- -	0 36 0 35 52	- - $\rightarrow 10^{14}$ $\rightarrow 10^{14}$ -	1.600 1.300 - -	- - 3-10 - 46	- - Melted - Carbonized
Polystyrene-black pigment (Styron)	0,025 0,100	Pile Pile	- -	0 54 0 54 66	- - $\rightarrow 10^{14}$ $\rightarrow 10^{14}$ -	1.100 1.100 - - -	- - 60 - 60	- - Carbonized - Carbonized
Polytetrafluoro-ethylene (	0,023 0,135 0,118	Pile Pile [illegible]	- - 7,25	0 1,5 0 0,5 0 [illegible]	- - $\rightarrow 10^{14}$ 1.10^{14} $\rightarrow 10^{15}$ $2,5.10^{14}$	1.100 800 - - - -	- - 300 250 - -	- - Electrode holder burned Melted - -

66/3020*5 cms

TABLE 11 (Continued) (4)

Polytetrafluoro-ethylene (cont..) (Teflon)		2,5(X)	0,5 1,08	0 0,4 0 0,2	$\rightarrow 10^{15}$ $4,2.10^{14}$ $\rightarrow 10^{15}$ $4,2.10^{14}$	- - - -	- - - -	- - - -
Polyvinylcarbazole (Polectron)	0,150	Pile	-	0 20	$\rightarrow 10^{14}$ $\rightarrow 10^{14}$	200 200	20 20	Carbonized Carbonized
Polyvinyl-chloride (Geon)	0,03	Pile	-	0 5,3	1.10^{13} 1.10^{6}	- -	- -	- -
Polyvinyl chloride acetate (Vinylite)	0,20 0,130	Pile Pile	- -	0 7,5 0 0,3 1 4,5	- - $\rightarrow 10^{14}$ $\rightarrow 10^{14}$ $< 10^{6}$	1,100 600 - - -	- - 70 20 10 0	- - Carbonized Carbonized Carbonized Carbonized
Polyvinylformal (Formvar)	0,005	Pile	-	0 3	1.10^{14} 1.10^{14}	- -	- -	- -
Polyvinyl vinylidene chloride (Saran)	0,030 0,130 0,118 0,118	Pile Pile 2,0 (e⁻) 2,5(X)	- - 5,2 11,7 23,4 0,06 0,35	0 22 0 0,27 0,39 0,61 1,4 0 0,4 0 0,4 0,7 0,8 0 0,8 0 0,017 0 0,017	- - 2.10^{14} 2.10^{13} 7.10^{12} 3.10^{9} 3.10^{7} $\rightarrow 10^{15}$ $7,8.10^{12}$ $\rightarrow 10^{15}$ $1,4.10^{14}$ $1,2.10^{13}$ 4.10^{13} $\rightarrow 10^{15}$ $1,2.10^{13}$ $\rightarrow 10^{15}$ 2.10^{14} $\rightarrow 10^{15}$ 2.10^{14}	630 230 - - - - - - - - - - - - - - - - -	- - - - - - - - - - - - - - - - - - -	- - - - - - - - - - - - - - - - - - -

66/5020/5 cms

TABLE 11 (Continued)(5)

Polvinyl vinylidine chlcride (Saran) (continued)			1,1	0 0,2 0,29	$\sim 10^{15}$ $1,4.10^{14}$ $7,2.10^{13}$	- - -	- - -	- - -

56/5020/5
cms

TABLE 12 (7) (8) (11) (48) (55) (56)

EFFECTS OF NUCLEAR RADIATION ON VOLUME RESISTIVITY, DIELECTRIC STRENGTH AND ARC RESISTANCE OF PLASTICS

B. THERMOSETTINGS

Material (Trade Names)	Specimen Thickness (inches)	Radiation Type and Energy in MeV	Dose rate* 10^{+7} rad/hr	Dose 10^{+8} rad	Volume Resistivity (ohm-cm)	Dielectric Strength Volts/mil	Arc Resistance seconds	Manner of failure
Aniline formaldehyde (Cibanite)	0.140	Pile	-	0	$\rightarrow 10^{14}$	200	20	carbonized
				30	$\rightarrow 10^{14}$	200	-	-
				40	-	-	20	carbonized
Furan resin, asbestos filled (Duralon)	0.175	Pile	-	0	1.10^{9}	55	4	carbonized
				30	-	55	-	-
				4[illegible]	1.10^{9}	-	[illegible]	carbonized
Melamine formaldehyde (Melmac)	0.175	Pile	-	0	1.10^{11}	200	190	carbonized
				1.7	-	-	130	carbonized
				4	-	-	120	carbonized
				[illegible]	-	-	[illegible]0	carbonized
				15	-	200	-	-
				22	1.10^{11}	-	70	carbonized
Phenol formaldehyde unfilled - (Catalin)	0.1[illegible]0	Pile	-	0	1.10^{12}	1[illegible]0	5	carbonized
				2	-	-	[illegible]	carbonized
				7	1.10^{12}	1[illegible]0	-	-
Phenol formaldehyde paper laminate (Bakelite)	0.125	Pile	-	0	$[illegible].10^{11}$	2[illegible]0	[illegible]	carbonized
				10	2.10^{14}	-	-	-
				1	-	240	-	-
				30	2.10^{11}	-	2	carbonized

* The irradiation in the pile took place at an approximate equivalent rate of 10^{6} to 10^{7} rads/hr.

66/5004/5) /mar

TABLE 12 continued

Phenol formaldehyde asbestos fibre filler (Bakelite)	0.130	Pile	-	0 51	2.10^{10} 3.10^{10}	150 200	4 4	carbonized carbonized
Phenol formaldehyde graphite filler (Karbate)	0.124	Pile	-	0 52	- -	70 70	- -	- -
Silicones mica filler (G.E. 1.132 impregnated 3.552)	0.016	Pile	-	0 [illegible] 20	10^{14} $[illegible].10^{11}$ -	254 - 196	- - -	- - -
Urea formaldehyde cellulose filler (Beetle)	0.125	Pile	-	0 1.5 3 4.5 [illegible] 1[illegible]	2.10^{13} - - - - 1.10^{11}	230 - - - 230 -	130 120 [illegible]0 60 - 20	carbonized carbonized carbonized carbonized - carbonized

65/5004/5. /mar

TABLE 13* (7) (6) (55) (57) (59) (60)

Material (Trade Name)	Thick-ness (mils)	Dielectric Constant				Dissipation Factor			
		Frequency=1kc		Frequency=1mc		Frequency=1kc		Frequency=1mc	
		Before irr.	After irr.	Before irr.	After irr.	Before irr.	After irr.	Before irr.	After irr.
A. Thermo-plastics									
Acrylonitrile-butadiene-styrene (Royalite)	50	2,93	2,96	2,85	2,89	0,0077	0,0071	0,013	0,013
Polyamide (Nylon 610)	70	3,94	3,36	3,21	3,11	0,059	0,013	0,036	0,021
Polyamide (Nylon 6)	65	6,1	4,14	3,70	3,55	0,11	0,023	0,064	0,033
Polyethylene-high density (Marlex)	55	2,35	2,32	2,35	2,31	0,000.11	0,000.78	0,000.04	0,000.78
Polyethylene-low density (Dylan)	[illegible]	2,25	2,23	2,28	2,27	0,000.04	0,001.4	0,000.12	0,000.94
Polyethylene-carbon filled	60	2,58	2,61	2,56	2,59	0,000.55	0,001.1	0,001.4	0,002.1
Polypropylene	53	2,29	2,25	2,25	2,21	0,000.65	0,002.9	0,000.65	0,001.3
Polystyrene (Amphenol)	65	2,51	2,51	2,53	2,53	0,000.14	0,000.11	0,000.26	0,000.24
Polyvinyl-chloride acetate (Vinylite)	16	3,19	3,5[illegible]	2,97	3,24	0,00[illegible].1	0,014	0,013	0,0[illegible]1

66/5009/5 /mar

Cont .. /..

TABLE 13* CONT.

Material (Trade Name)	Thickness (mils)	Dielectric Constant Frequency=1kc Before irr.	After irr.	Frequency=1mc Before irr.	After irr.	Dissipation Factor Frequency=1kc Before irr.	After irr.	Frequency=1mc Before irr.	After irr.
Polyvinyl Fluoride	5	3,69	3,46	3,61	3,40	0,0023	0,00[illegible]9	0,029	0,031
Styrene butadiene high impact (Pliotuf)	[illegible]5	2,49	2,51	2,49	2,4[illegible]	0,000.41	0,0018	0,000.[illegible]	0,000.25
B. Thermosettings									
Diallyl phthalate (Plaskor)	[illegible]	4,1[illegible]	4,[illegible]	4,17	4,20	0,01[illegible]	0,010	0,013	0,013
Epoxy moulding - mineral filled (Araldite)	[illegible]	[illegible],7[illegible]	9,50	7,77	7,69	0,046	0,051	0,056	0,041
Phenolic - asbestos filled (Bakelite)	70	10,4	[illegible],31	6,1[illegible]	5,71	0,15	0,13	0,00[illegible]6	0,06[illegible]
Polyethylene terephthalate (Mylar)	5	3,05	3,06	2,95	2,94	0,0022	0,0038	0,012	0,011

* The irradiations were carried out in a Van der Graaff accelerator operated with a dose rate of 3.10[illegible] rad/hr. All the plastics are subjected to a radiation dose of about 1.10^9 rad.

65/5006/5 /mar

TABLE 14

Gasevolution * (7) (8) (11) (61) (62) (63) (64)

Material - Thermoplastic	Gas evolved - ml/g. at 10^9 rads.
Allyl diglycol carbonate	40-55
Casein	4-7
Cellulose Acetate	17-20
Cellulose Acetate Butyrate	28-30
Cellulose propionate	35
Cellulose Nitrate	105-120
Ethylcellulose	30-35
Polyamide	20-25
Polychlorotri fluoroethylene	3.5
Polyethylene	70
Polyethylene terephthalate	3-5
Poly α- methylstyrene	1,5-10
Polymethylmethacrylate	30-35
Polypropylene	70-90
Polystyrene	1-1,5
Polytetrafluroethylene	0,5-1,2
Polyvinylalcohol	25-40
Polyvinylchloride	6-9
Polyvinyl formal	~100
Styrene-butadiene plastic	~2
Triallyl cyanurate polymer	~2

TABLE 15

Gasevolution * * (7) (8) (11) (61) (62) (63) (64)

Material - Thermosettings	Gas evolved - ml/g. at 10^9 rads.
Aniline formaldehyde	~ 2
Furan resin	< 0,15
Melamine formaldehyde (cellulose filler)	6-10
Phenol formaldehyde	
No filler	5
Linen fabric filler	14
Paper filler	17
Asbestos filler	< 0,15
Graphite filler	< 0,05
Polyesters (general)	2-40
Urea formaldehyde (cellulose filler)	10-17

* The gasevolution was measured from samples of 0,2 to 0,5 gramme

66/6010/5

sp.

TABLE 16 (7) (11)

Effect of filler material on the radiation stability of phenol formaldehyde.

Material	Additive — Filler	Relation Stability of filler	Threshold Damage (rads)	25 % Damage Dosage (rads)
Phenol formaldehyde	None		$2{,}7 \cdot 10^{6}$	$1{,}1 \cdot 10^{7}$
Phenol formaldehyde	Asbestos fiber	Better	$7{,}8 \cdot 10^{7}$	$8{,}9 \cdot 10^{8}$
Phenol formaldehyde	Asbestos	Better	$3{,}9 \cdot 10^{8}$	$3{,}9 \cdot 10^{9}$
Phenol formaldehyde	Graphite	Better	$8{,}9 - 10^{5}$	$7{,}7 \cdot 10^{7}$
Phenol formaldehyde	Linen fabric laminate	Less	$3{,}4 \cdot 10^{5}$	$8{,}2 \cdot 10^{6}$
Phenol formaldehyde	Paper	Less	$3{,}8 \cdot 10^{5}$	$2{,}6 \cdot 10^{7}$

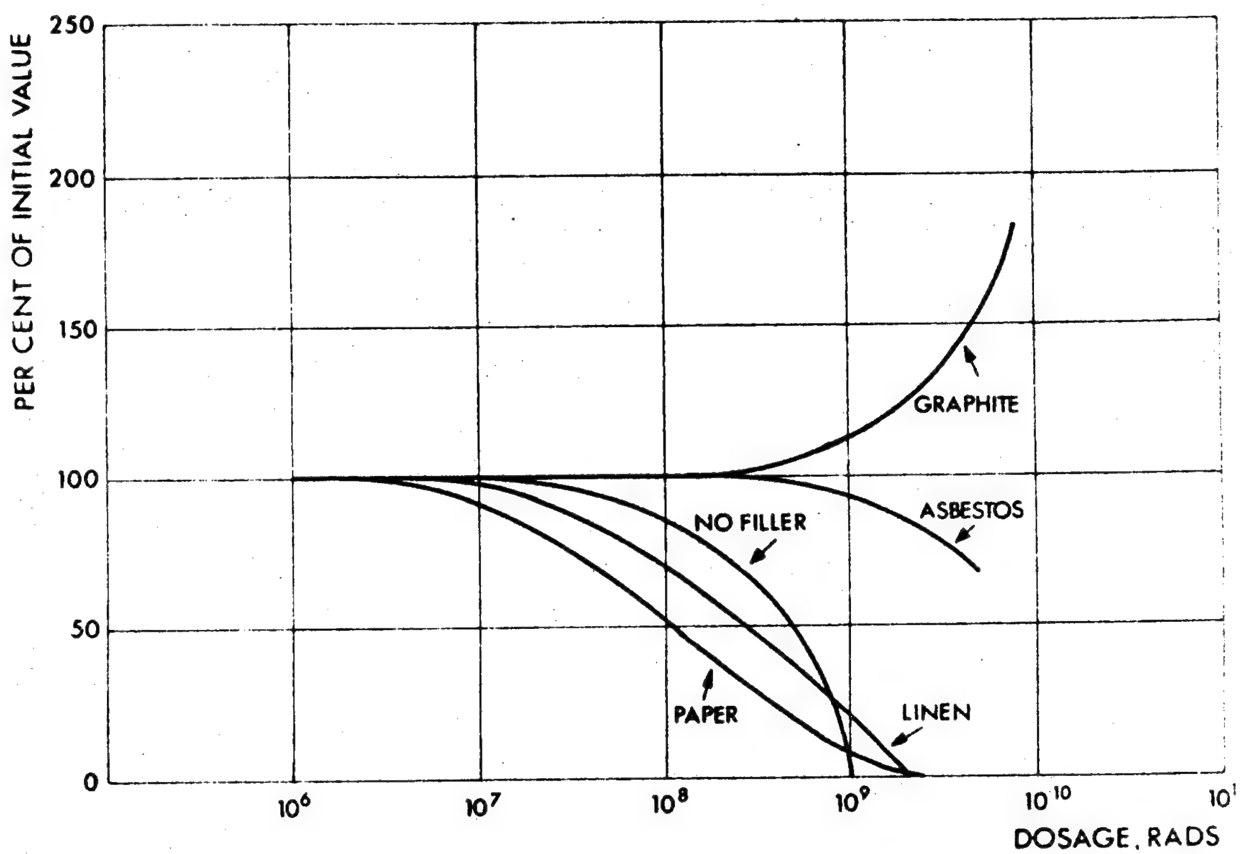


Fig. 44

EFFECT OF FILLERS ON THE TENSILE STRENGTH OF PHENOL FORMALDEHYDE RESINS AFTER IRRADIATION (7,9,11)

TABLE 17

Effects of fillers on the elongation of polyvinylchloride (65)

	0	$1x10^8$	$2x10^8$
No filler	100	78	58
Carbon black	100	79	64
T_iO_2, rutile	100	73	54
Whiting	100	73	42
China Clay	100	82	65

66/5018/5
mf

TABLE 13

Effect of fillers on the radiation stability of polyester - and silicone resins (66)

Material	Filler	EXPOSURE : rads.		
		Threshold	25% damage	50% damage
Polyester	unfilled	6.10^{5}	10^{6}	$5.10^{[illegible]}$
	glass fibre	6.10^{8}	5.10^{9}	10^{10}
	Mineral	7.10^{7}	1.10^{9}	4.10^{9}
Silicone	unfilled	10^{8}	4.10^{8}	$2.10^{[illegible]}$
	glass fibre	1.10^{8}	10^{10}	8.10^{10}
	Mineral	1.10^{8}	-	-

No. 66/5013/e
jp.

TABLE 19

Radiation stability of plastics at temperatures above 75°C (11) (67) (68)

Material-Thermoplastic	Temp. °C	Max.dose (electrical) rads	Max.dose (Mechanical) rads
Casein	125-140	-	$2,5 \times 10^{7}$
Monochlorotrifluoroethylene	200	5×10^{8}	5×10^{6}
Polyamide	100	5×10^{8}	$2,5 \times 10^{8}$
Polyethylene	85	5×10^{9}	$2,5 \times 10^{8}$
Polystyrene	75	5×10^{9}	5×10^{8}
Polytetrafluoroethylene	250	$2,5 \times 10^{9}$	$2,5 \times 10^{5}$
Polyvinylacetate	130	5×10^{8}	$2,5 \times 10^{8}$
Polyvinylcarbazole	150	5×10^{9}	5×10^{8}
Polyvinylchloride	85	10^{9}	5×10^{7}
Polyvinylformal	130	10^{9}	5×10^{8}

TABLE 20

Radiation stability of plastics at temperatures above 75°C. (11) (67) (68)

Material - Thermosettings	Temp. °C	Max . dose (Electrical) rads	Max . dose (Mechanical) rads
Epoxy	130	5×10^9	2×10^9
Furan	120 - 160	—	$3{,}3 \times 10^9$
Melamine formaldehyde			
Cellulose filler	110	—	1×10^8
Glass fibre filler	120	—	1×10^8
Phenol formaldehyde			
No filler	120	—	$1{,}1 \times 10^7$
Cellulose Filler	120	—	$2{,}8 \times 10^6 - 2{,}6 \times 10^7$
Mineral filler	175 - 190	—	$7{,}7 \times 10^7 - 3{,}9 \times 10$[illegible]
Polyester			
No filler	100	—	$8{,}7 \times 10^5$
Mineral filler	110	—	$3{,}9 \times 10^9$
Silicones	150	5×10^9	$2{,}5 \times 10^8$

TABLE 21

TRADE NAMES OF PLASTICS

Trade Name	Chemical Name
Abcolite	Polystyrene
Abson	Acrylonitrile butadiene styrene
Acrolite	Urea Formaldehyde
Alathon	Polyethylene
Agilene	Polyethylene
*Algoflon	Polytetrafluoroethylene (P.T.F.E.)
Alkathene	Polyethylene
Alphalux 400	Polyphenylene oxyde
Ameroid	Casein
Ampacet	Polystyrene
Araldite	Epoxy
Aropol	Polyester
Atlac	Polyester
*Agilide	Polyvinylchloride

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B)

Trade Name	Chemical Name
Bakelite	Phenolic
Beetle	Urea Formaldehyde
Bexoid	Cellulose acetate
Butacite	Polyvinyl Butyral

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yr

c)

Trade Name	Chemical Name
Caladene	Phenolic
Capran Film	Nylon 6
Cariflex	Butadiene styrene
Carina	Polyvinylchloride
Carlona	Polyethylene
Carlona P	Polypropylene
Catabond	Polyester
Catalin	Phenolic
Ceapren	Polyester
Cellidor	Cellulosics
Cellit	Cellulosics
Cellophane	Cellulosics
Cellofoam	Polystyrene
Cibanite	Aniline Formaldehyde
Covisil	Silicones
CR 39	Polycarbonate
Crystic	Polyester
Cycolac	ABS
Cymel	Melamine Formaldehyde

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Trade Name	Chemical Name
Dacron	Polyester
Dapon	Polyester
Darvic	Polyvinylchloride
D.C. Resins	Silicones
Delrin	Acetal
Desmodur	Polyurethane
Devcon	Epoxy
Diakon	Polymethylmethacrylate
Diorit	Polyvinylidenechloride
Dow Corning	Silicones
Duralon	Furan
Durez	Phenolic
Durite	Phenolic
Duthane	Polyurethane
Dylan	Polyethylene

E)

Trade Name	Chemical Name
Epiall	Epoxy
Epikote	Epoxy
Epons	Epoxy
Epophen	Epoxy
Epoxylite	Epoxy
Erinoid	Casein
Estane	Polyurethane
Ethocel	Ethyl cellulose
Exon	Polyvinylchloride

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yr

F)

Trade Name	Chemical Name
Flexon	Polyvinylchloride
Fluon	P.T.F.E.
Fluorothene	Polytrifluoromonochlorsethylene (P.C.T.F.E.)
Formica	Melamine Formaldehyde
Formvar	Polyvinylformal
Forticel	Cellulosics

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yr

c)

Trade Name	Chemical Name
Gabraster	Polyester
Gabrite	Urea Formaldehyde
Gansolite	Casein
Gedex	Polystyrene
Gelva	Polyvinylacetate
Gelvatol	Polyvinylalcohol
Geon	Polyvinylchloride
Glidpol	Polyester
Grilon	Polyamide

66/5021/5
yr

H)

Trade Name	Chemical Name
H Film	Polyimide
Halon	P.T.F.E.
Haveg	Phenolic
Hetron	Polyester
Hifax	Polyethylene
Hostaflon	Polytrifluoromonochloroethylene
Hostaflon TF	Polytetrafluoroethylene
HT Film	Polyimide
Hypalon	Chloro sulfonated polyethylene

66/5021/5
yr

K)

Trade Name	Chemical Name
Kapton	Polyimide
Karbate	Phenolic
Kel F	Polytrifluoromonochloroethylene
Koroseal	Modified Polyvinylchloride
Kralastic	ABS
Kynar	Polyvinylidene Fluoride

66/5021/5
yr

L)

Trade Name	Chemical Name
Lactophane	Cellulosics
Laminac	Polyester
Leguval	Polyester
Lekutherm	Epoxy
Lexan	Polycarbonate
Lucite	Polymethylmethacrylate
Lustran	ABS (Acrylonitrile butadiene styrene)
Lustrex	Polystyrene
Luvican	Polyvinylcarbazol

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M)

Trade Name	Chemical Name
Marblette	Phenolic
Marco MR	Polyesters
Marform	Polyurethane
Marlex	Polyethylene
Marvinol	Polyvinylchloride
Melinex	Polyethylene Terephthalate
Melmac	Melamine Formaldehyde
Melox	Melamine Formaldehyde
Merlon	Polycarbonate
Micarta	Phenolic
Mondur	Isocyanates
Monsanto	Polystyrene
Mylar	Polyethylene terephthalate
3M	Epoxy

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yr

n)

o)

Trade Name	Chemical Name
Nailonplast	Polyamide
Nomex Yarn	Polyimide
Nylon	Polyamide

Trade Name	Chemical Name
Opalon	Polyvinylchloride
Orizon	Polyethylene

P)

Trade Name	Chemical Name
PPO	Polyphenylene oxide
Paraplex	Polyester
Parylene N, C, D	Parylene
Penton	Chlorinated Polyether
Perlon	Polyamide
Perspex	Polymethylmethacrylate
Petrothene	Polyethylene
Phenolite	Phenolic
Plaskon Alkyd	Polyester
Plastacele	Cellulose acetate
Pleogen	Polyester
Plexiglas	Polymethylmethacrylate
Pliolite	Styrene-butadiene
Pliovic	Polyvinylchloride
Plyophen	Phenolic
Polectron	Polyvinylcarbazole
Polydur	Polyethylene
Polyflon	Polytetrafluoroethylene
Polyox	Polyethyleneoxyde
Polystyrole	Polystyrene
Polythene	Polyethylene
Polytherm	Polyvinylchloride
Pro-Fax	Polypropylene
Pyraline	Cellulose nitrate

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yr

R)

Trade Name	Chemical Name
Resimene	Melamine
Resinol	Phenolic
Resinox	Phenolic
Résocel	Phenolic
Résofil	Phenolic
Rosite 2000	Phenolic
Rayolin	Polyolefin
Royalite	ABS

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S)

Trade Name	Chemical Name
Saflex	Polyvinylbutyral
Saran	Polyvinylidene chloride
Saran F	Polyvinylchloride
Selectron	Polyester
Silastic 80	Silicones
Silmar	Polyester
Solithane	Polyurethane
Sonoplas	Polyvinylchloride
Soreflon	Polytetrafluoroethylene
Styrex	Polystyrene
Styron	Polystyrene
Styrofoam	Polystyrene
Sylgand	Silicones
Swilyn	Ionomer
Synvaren	Phenolics
Synvarite	Phenolics
Synvarol	Ureaformaldehyde

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yr

T)

Trade Name	Chemical Name
Tedlar	Polyvinylfluoride
Teflon	Polytetrafluoroethylene
Teflon FEP	Copolymer of hexafluoropropene and tetrafluoroethylene
Tenite Butyrate	Cellulose Acetate butyrate
Terylene	Polyethylene Terephthalate
Tetran	Polytetrafluoroethylene
Texin	Polyurethane
Thiokol	Polysulfide
Triacel	Cellulose acetate
Trulon	Polyvinylchloride
Tufnol	Phenolic
Tybrene	ABS
Tygon	Polyvinylchloride

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yr

u)

Trade Name	Chemical Name
Ultron	Polyvinylchloride
Union Carbide	Silicones
Urox	Urea Formaldehyde

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yr

v)
w)
x)
z)

Trade Name	Chemical Name
Varcum	Phenolic
Velon	Polyvinylidene chloride
Vestan	Polyvinylidene chloride
Vibrathene	Polyester
Vibrin	Polyester
Viscose	Cellulosics
Vinidur	Polyvinylchloride
Vybak	Polyvinylchloride
Vinylite A	Polyvinyl acetate

Trade Name	Chemical Name
Welvic	Polyvinylchloride

Trade Name	Chemical Name
Xylonite	Cellulosics

Trade Name	Chemical Name
Zytel	Polyamide

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TABLE 22

A)

Chemical Name	Trade Name
ABS (Acrylonitrile butadiene styrene)	Cycolac
ABS " " "	Kralastic
ABS	Lustran
ABS	Royalite
ABS	Tybrene
Acetal	Delrin
Acrylonitrile Butadiene Styrene	Abson
Aniline formaldehyde	Cibanite

B)

<u>Chemical Name</u>	<u>Trade Name</u>
Butadiene Styrene	Cariflex

c)

Chemical Name	Trade Name
Carbonate	CR 39
Casein	Ameroid
Casein	Gansolite
Cellulose acetate	Bexoid
Cellulose acetate	Plastacele
Cellulose acetate	Triacel
Cellulose acetate butyrate	Tenite butyrate
Cellulose nitrate	Pyraline
Cellulosics	Collidor
Cellulosics	Forticel
Cellulosics	Cellit
Cellulosics	Cellophane
Cellulosics	Lactophane
Cellulosics	Viscose
Cellulosics	Xylonite
Chlorinated polyether	Penton
Chloro sulfonated polyethylene	Hypalon
Copolymer of hexa fluoropropene and tetrafluoroethylene	Teflon F E P

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E)

Chemical Name	Trade Name
Epoxy	Araldite
Epoxy	Devcon
Epoxy	Epiall
Epoxy	Epikote
Epoxy	Epons
Epoxy	Epophen
Epoxy	Epoxylite
Epoxy	Lekutherm
Epoxy	3 M
Ethyl Cellulose	Ethocel

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Chemical Name	Trade Name
Furan	Duralon

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yr

I)

Chemical Name	Trade Name
Ionomer	Swilyn
Isocyanates	Mondur

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yr

M)

Chemical Name	Trade Name
Melamine formaldehyde	Cymel
Melamine formaldehyde	Formica
Melamine formaldehyde	Melmac
Melamine formaldehyde	Melox
Melamine	Resimene
Modified polyvinylchloride	Koroseal

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yr

N)

Chemical Name	Trade Name
Nylon 6	Capran film

P) -1-

Chemical Name	Trade Name
Parylene	Parylene
P.C.T.F.E. (Polytrifluoromonochloroethylene)	Fluorothene
P.C.T.F.E. "	Hostaflon
P.C.T.F.E. "	Kel F.
Phenolic	Bakelite
Phenolic	Catalin
Phenolic	Durez
Phenolic	Haveg
Phenolic	Karbate
Phenolic	Micarta
Phenolic	Phenolite
Phenolic	Plyophen
Phenolic	Resinol
Phenolic	Resinox
Phenolic	Résocel
Phenolic	Résofil
* Phenolic	Synvaren
Phenolic	Synvarite
Phenolic	Tufnol
Polyamide	Grilon
Polyamide	Nailonplast
Polyamide	Nylon
Polyamide	Perlon
Polyamide	Zytel
Polycarbonate	CR 39
Polycarbonate	Lexan
Polycarbonate	Merlon
Polyester	Aropol
Polyester	Atlac
Polyester	Catabond
Polyester	Ceapren
Polyester	Crystic
* Phenolic	Varcum

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-2-

Chemical Name	Trade Name
Polyester	Dacron
Polyester	Dapon
Polyester	Gebraster
Polyester	Glidpol
Polyester	Hetron
Polyester	Laminac
Polyester	Leguval
Polyesters	Marco MR
Polyester	Paraplex
Polyester	Plaskon Alkyd
Polyester	Pleogen
Polyester	Selectron
Polyester	Silmar
Polyester	Vibrathane
Polyester	Vibrin
Polyethylene	Alathon
Polyethylene	Agilene
Polyethylene	Alkathene
Polyethylene	Carlona
Polyethylene	Dylan
Polyethylene	Hifax
Polyethylene	Marlex
Polyethylene	Orizon
Polyethylene	Petrothene
Polyethylene	Polydur
Polyethylene	Polythene
Polyethyleneoxyde	Polyox
Polyphenylene oxyde	PPO
Polyethylene terephthalate	Melinex
Polyethylene terephthalate	Mylar
Polyethylene terephthalate	Terylene
Polyimide	H Film

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P) -3-

Chemical Name		Trade Name
Polyimide		H Film
Polyimide		Kapton
Polyimide		Nomex yarn
Polymethylmethacrylate		Diakon
Polymethylmethacrylate		Lucite
Polymethylmethacrylate		Perspex
Polymethylmethacrylate		Plexiglas
Polyolefin		Rayolin
Polyphenylene oxyde		Alphalux 400
Polypropylene		Carlona P
Polypropylene		Pro - Fax
Polystyrene		Abcolite
Polystyrene		Ampacet
Polystyrene		Cellofoam
Polystyrene		Gedex
Polystyrene		Lustrex
Polystyrene		Monsanto
Polystyrene		Styrex
Polystyrene		Styron
Polystyrene		Styrofoam
Polysulfide		Thiokol
Polytetrafluoroethylene	(P.T.F.E.)	Algoflon
Polytetrafluoroethylene		Fluon
Polytetrafluoroethylene		Halon
Polytetrafluoroethylene		Hostaflon TF
Polytetrafluoroethylene		Polyflon
Polytetrafluoroethylene		Soreflon
Polytetrafluoroethylene		Teflon
Polytetrafluoroethylene		Tetran
Polyurethane		Desmodur
Polyurethane		Duthane

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P) -4-

Chemical Name	Trade Name
Polyurethane	Estane
Polyurethane	Marfoam
Polyurethane	Solithane
Polyurethane	Texin
Polyvinylacetate	Gelva
Polyvinylacetate	Vinylite A
Polyvinylalcohol	Gelvatol
Polyvinylbutyral	Butacite
Polyvinylbutyral	Saflex
Polyvinylcarbazol	Luvican
Polyvinylcarbazol	Polectron
Polyvinylchloride	Agilide
Polyvinylchloride	Carina
Polyvinylchloride	Darvic
Polyvinylchloride	Exon
Polyvinylchloride	Flexon
Polyvinylchloride	Geon
Polyvinylchloride	Marvinol
Polyvinylchloride	Opalon
Polyvinylchloride	Pliovic
Polyvinylchloride	Polytherm
Polyvinylchloride	Saran F
Polyvinylchloride	Somaplas
Polyvinylchloride	Trulon
Polyvinylchloride	Tygon
Polyvinylchloride	Vinidur
Polyvinylchloride	Vybak
Polyvinylchloride	Welvic
Polyvinylfluoride	Tedlar
Polyvinylformal	Formvar
Polyvinylidenechloride	Diorit

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yr

P) -5-

Chemical Name	Trade Name
Polyvinylidene chloride	Saran
Polyvinylidene chloride	Velon
Polyvinylidene fluoride	Kynar
Polyvinylidene chloride	Vestan

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yr

s)

Chemical Name	Trade Name
Silicones	Covisil
Silicones	D.C. Resins
Silicones	Dow Corning
Silicones	Silastic 80
Silicones	Sylgard
Silicones	Union Carbide
Styrene Polymers	See Polystyrene
Styrene Butadiene	Pliolite

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U)

Chemical Name	Trade Name
Urea Formaldehyde	Acrolite
Urea Formaldehyde	Beetle
Urea Formaldehyde	Gabrite
Urea Formaldehyde	Synvarol
Urea Formaldehyde	Urox

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